May 13, 1957 50 Cents

AVIATION WEEK

A McGRAW-HILL PUBLICATION

T2J Designed as All-Phases Trainer

•

CAB's Report on Canyon Collision

Lacrosse Surface-to-Surface Missile

he's watching the progress of the Air Age from his machine...

Piston engines . . . jets . . . and now, missiles, Foote Bros. craftsmen are watching the steady advance of American air progress from their machines. They're not only watching it—they are an important part of it, because, at this moment they are helping produce components capable of performance undreamed of a short time ago.

At Foote Bros., yesterday's technology, methods and standards of precision are obsolete. Today, these men are working with new metals in new ways, with greater precision, to produce lighter, stronger and more reliable gearing, power transmission and actuating mechanisms for the air age of tomorrow.

It is the willingness to innovate, the ability to anticipate, and the determination to excel that have helped Foote Bros. engineers and production men keep pace with, and earn the confidence of, the aviation industry.

We may be able to help solve your problems involving precision gearing and actuating mechanisms, and would welcome the opportunity of talking with you.

this trademark stands for the finest industrial gearing made

FOOTE BROS.

Better Power Transmission Through Better Gears

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Probably the widest wheel ever built for its rolling diameter, it's of forged magnesium by Goodyear — mounts dual tires, saves weight, stays within space limitation.

Goodyear Tri-Metallic Brakes are the key to the braking ability of the B-58. Non-insulating-type lining allows up to 50% increase of kinetic energy absorption per pound of brake.

ON MAIN WHEELS AND BRAKES *by Goodyear!*

Main wheels and brakes for the Convair B-58—designed, engineered and produced by Goodyear Aviation Products to meet this foremost jet bomber's space, speed and load requirements.

For information on advanced wheel and brake engineering, write: Goodyear, Aviation Products Division, Akron 16, Ohio, or Los Angeles 54, California.

GOODYEAR AVIATION PRODUCTS

More aircraft the world over land on Goodyear Tires, Wheels and Brakes than on any other kind!

the world's largest manufacturing facilities for aircraft seating... for aircraft interior equipment

THE SEAT* OF THE INDUSTRY IS WEBER

For your requirements in aircraft passenger and crew seats, buffets and lavatories... a very specialized manufacturing capability is demanded. In all the world there is only one such Single Source, having the complete facilities... the full design staff... the age, stability and strength... the after-sale service standards... and the vision.

That Single Source... is Weber. So first take your requirements to the seat of modern airlines seating... Weber.

A World of experience in: Passenger seats, Pilot and Crew Seats, Buffets, lavatory units and kindred aircraft interior equipment.

*SEAT: "The place where anything... is settled or established" —Winston Dictionary

WEBER AIRCRAFT CORPORATION

a subsidiary of Weber Showcase and Fixture Company, Inc.

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AVIATION CALENDAR

May 13-14—What the Rocket and Missile Program Means to the Chemical Industry, Spring Meeting, Commercial Chemical Development Assn., French Lick, Ind.

May 13-15—National Conference on Aeronautical Electronics, Sponsored by the Institute of Radio Engineers, Dayton, Ohio.

May 14—Engine Operation & Maintenance Forum sponsored by Pratt & Whitney Aircraft Division and distributors, Pacific Airmotive Corp., Cosmopolitan Hotel, Denver, Colo. Other sessions, May 17 at Ambassador Hotel, Burbank, Calif.; May 20 at Hotel Claremont, Oakland, Calif., and May 22, New Washington Hotel, Seattle, Wash.

May 15-17—Jet Age Airport Conference, Air Transport Division, American Society of Civil Engineers, Park-Sheraton Hotel, New York.

May 20—Annual Meeting and award of Daniel Guggenheim Medal, University Club, 1 W. 54 St., New York.

May 20—Sixth Annual Aviation Fire Safety Seminar, National Fire Protection Assn., Hotel Statler, Los Angeles, Calif.

May 20-22—1957 Design Engineering Conference American Society of Mechanical Engineers, Coliseum, New York.

May 23—Gunter Loeser Memorial Lecture, Progress and Prospects of Radar Meteorology, Dr. David Atlas, Charter Rm., New England Mutual Bldg., Boston, Mass.

May 24-June 2—22nd Paris Air Show, Society of French Aircraft Constructors, LeBourget Airport, Paris.

May 27-29—National Telemetering Conference, Hotel Cortez, El Paso, Tex.

May 28-29—Annual Business Aircraft Safety Seminar, sponsored by Flight Safety Foundation, Park Sheraton Hotel, New York.

May 30-June 2—Wright Memorial Glider Meet, sponsored by Soaring Society of Dayton, Cox Municipal Airport, Dayton.

June 1—8th Annual Maintenance and Operations Meeting for Business and Ex-

(Continued on page 6)

AVIATION WEEK • MAY 13, 1957

Vol. 66, No. 19

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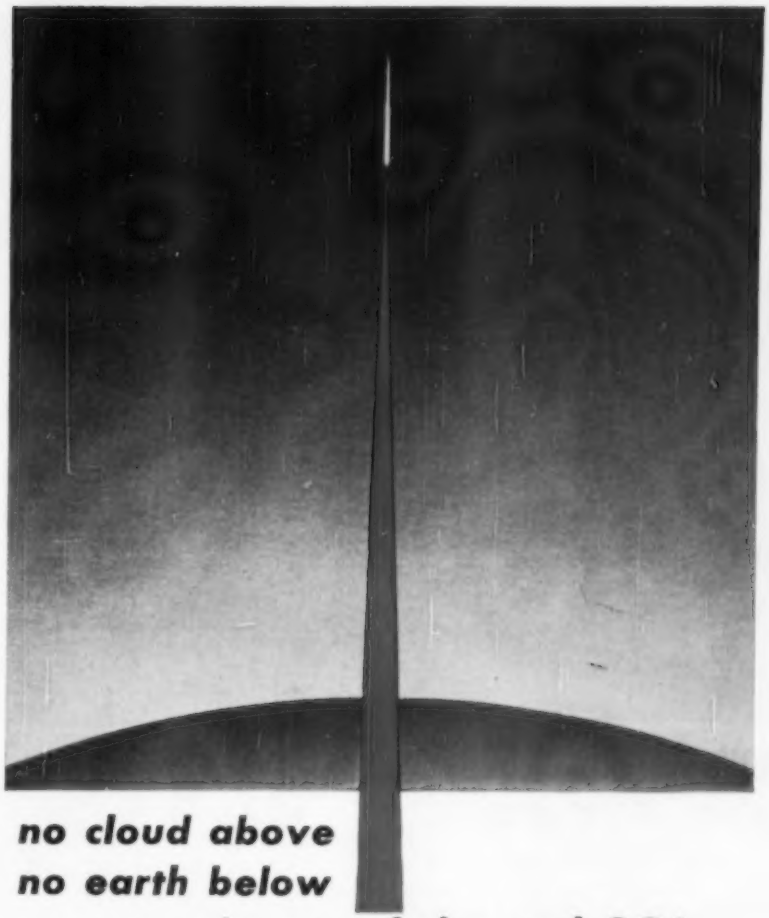

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Advanced missiles are blazing new trails in the universe of outer space . . . and precision components help determine the success of their high speed, high altitude course.

Experience, skilled personnel and modern facilities at Lavelle are focused on the precision fabrication of Missile, Engine, Airframe, and Electronic components in titanium, aluminum, stainless steel and other heat resistant, high strength alloys . . . to the most rigid specifications.

Ram jet engine cone and diffuser sections, fuel manifolds, flame holders, combustion chambers and liners are typical components made by Lavelle for major manufacturers. They rely on Lavelle's quality workmanship, dependable delivery and reasonable costs.

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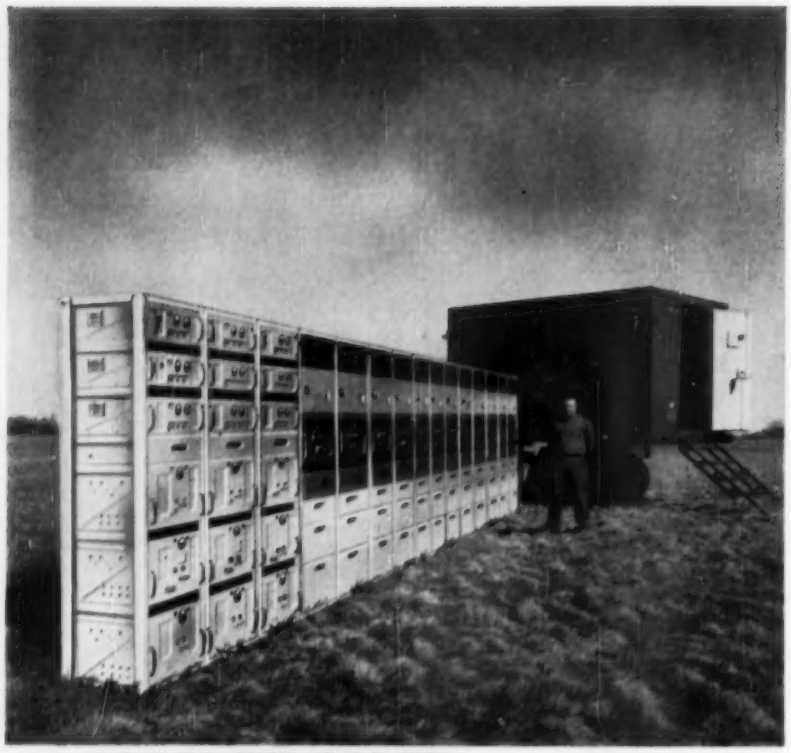

New **VAN TRAILER** by Craig
houses all this equipment . . . with room to spare!

There's plenty of room inside the new insulated Craig Van Trailer LM-105! With its big 7,000 pound payload and roomy 575 cubic foot interior, this rugged van trailer can house 15 standard 6-foot racks, fully loaded with electronic equipment — and still allow ample space for operation and maintenance.

Whatever the load — a complete electronic system, test equipment, mobile maintenance shop, or you-name it — your equipment arrives quickly and safely in the LM-105. This versatile van trailer meets Government specifications for world-wide, all-weather use.

Quick facts about the LM-105:

WEIGHT: Approximately 4,000 pounds including dolly.

PAYLOAD: 7,000 pounds.

DIMENSIONS: (Inside) 140 inches long, 90 inches wide, 79 inches high.

INSULATION: overall shelter has U-Factor of 0.30.

FEATURES INCLUDE: aluminum-faced honeycomb panel construction; lighting system; power distribution box; cable entry ports; stairs; jacks for levelling; and a quickly detachable dolly with coil spring and torsion bar suspension, air-over-hydraulic brakes, and single beam towing tongue.

ACCESSORY EQUIPMENT AVAILABLE: includes air conditioner, heater, workbench, racks, cabinets, spare parts containers, etc.

AIR TRANSPORTABLE: By C-119 or larger cargo aircraft.

ELECTRONIC INSTALLATION: Craig provides complete layout and installation of equipment including wiring and component check-out.

Van Trailer LM-105, front view, with jacks in position.

For further information, write Craig today!

Craig SYSTEMS, INC. *Dept. N-5, Danvers, Mass. Tel.: SPring 4-1870.*

WESTERN DIVISION: *6214 West Manchester Avenue, Los Angeles, 45, California ORegon 8-0025.*

OTHER CRAIG PRODUCTS . . . . *transportable and mobile electronic systems, shelters, trailers, vans, mobile control towers, missile carriers, re-usable containers, antenna towers and masts.*

AVIATION CALENDAR

(Continued from page 5)

ecutive Aircraft Owners, sponsored by Reading Aviation Service, Reading Municipal Airport, Pa.

June 3-5—First General Aviation Law-Science Seminar, Wichita University, Kans.

June 4-5—Symposium on Materials for Electronic Components, University of Pennsylvania, Philadelphia, Pa.

June 6-7—National Symposium on (Electronic) Production Techniques, Willard Hotel, Washington, D. C.

June 8-12—Technical Personnel Recruiting Exposition, in conjunction with National Technical Career Conference, Sherman Hotel, Chicago, Ill.

June 9-14—Semi-Annual Meeting, American Society of Mechanical Engineers, Sheraton Palace Hotel, San Francisco, Calif.

June 10-14—Lecture Series on Vacuum Metallurgy, sponsored by New York University College of Engineering. Address inquiries to: Dr. R. F. Bunshah, N. Y. University College of Engineering, University Heights 53, N. Y.

June 11-13—3rd Western Plant Maintenance & Engineering Conference, Civic Auditorium, San Francisco, Calif.

June 14—Plastics for Electronics, New England Section, Society of Plastics Engineers, Lowell Technological Institute, Lowell, Mass.

June 17-19—National Convention on Military Electronics, Sheraton-Park Hotel, Washington, D. C., sponsored by Institute of Radio Engineers.

June 17-20—Eighth All Women's International Air Race, McAllen, Tex.-Cuba. For details, write: Miss Irma Price, Entry Chief, 242 W. 8th St., Miami, Fla.

June 17-20—National Summer Meeting, Institute of the Aeronautical Sciences, Biltmore Hotel, Los Angeles, Calif.

June 23-25—29th Annual Meeting, Aviation Distributors & Manufacturers Assn., The Broadmoor, Colorado Springs, Colo.

June 24—Soviet National Aviation Day, Moscow.

June 27-29—13th Annual Meeting, Institute of Navigation, Sheraton-Park Hotel, Washington, D. C.

July 6-10—Eleventh All-Women Transcontinental Air Race, from San Mateo County Airport, Carlos, Calif., to North Philadelphia Airport, Pa.

July 10-20—International British Plastics Exhibition, Olympia London Grand & National Halls, England.

July 12-13—British Lockheed International Acrobatic Competition, the National Air Races (third round) and the King's Cup Air Race, Coventry Civil Aerodrome, Bagington, England.

July 31-Aug. 4—Eleventh Annual National Convention, Air Force Assn., and Airpower Panorama, Sheraton-Park and Shoreham Hotels, Washington, D. C.

Aug. 20-23—Western Electronic Show & Convention, Cow Palace, San Francisco.

Sept. 1-6—Sixth International Aeronautical Conference, Royal Aeronautical Society and Institute of the Aeronautical Sciences, Folkstone and London, England.

Sept. 2-8—1957 Flying Display, Society of British Aircraft Constructors, Farnborough, England.

How Holley's Compressor Governors Help New Jets to Supersonic Speeds

"City-savers" Air Force men call them: the J-57-powered F-100, F-101, F-102 and Navy F8U, with level flight speeds faster than sound. And city-savers they could well be. Certainly their rapid approach to the fringe of Mach 2 heralds a new era in the progress of jet flight.

Sharing in the development of this new brood of supersonic fighters, Holley engineers, working closely with Pratt & Whitney Aircraft on the J-57 engine, designed the compressor bleed governor.

This new Holley compressor bleed governor is one more example of Holley's continuing leadership in the design, development and manufacture of superior engine control systems for both military and civilian use.

Leader in the design, development, and manufacture of aviation fuel metering devices.

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A-24

Stroukoff C-134

The first Pantobase-BLC transport

SPECIFICATIONS

WING SPAN – 110 FT.

FUSELAGE LENGTH – 82 FT.

CARGO AREA – 4200 CU. FT.

Powered by two R 3350 – 89A Wright Turbo-compound engines

The usefulness of military transport aircraft has been extensively increased with the introduction of the Stroukoff C-134. Produced for the United States Air Force this rugged heavyweight requires extremely short take-off and landing runs and can operate from any prepared or unimproved surface–snow, ice, sand, water, etc. Advanced airframe design has been combined with Stroukoff Pantobase and Boundary Layer Control Systems to produce a new type of aircraft equipped for a variety of assault and logistic missions requiring operation without the limitation of conventional runways.

The Stroukoff C-134 is destined for an important role in modern military strategy.

Interesting opportunities for qualified engineers in many fields exist at Stroukoff. If your skills are not being used to full capacity, write us today. Your inquiry is confidential, of course.

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EDISON MINIATURE -- HI-TEMP

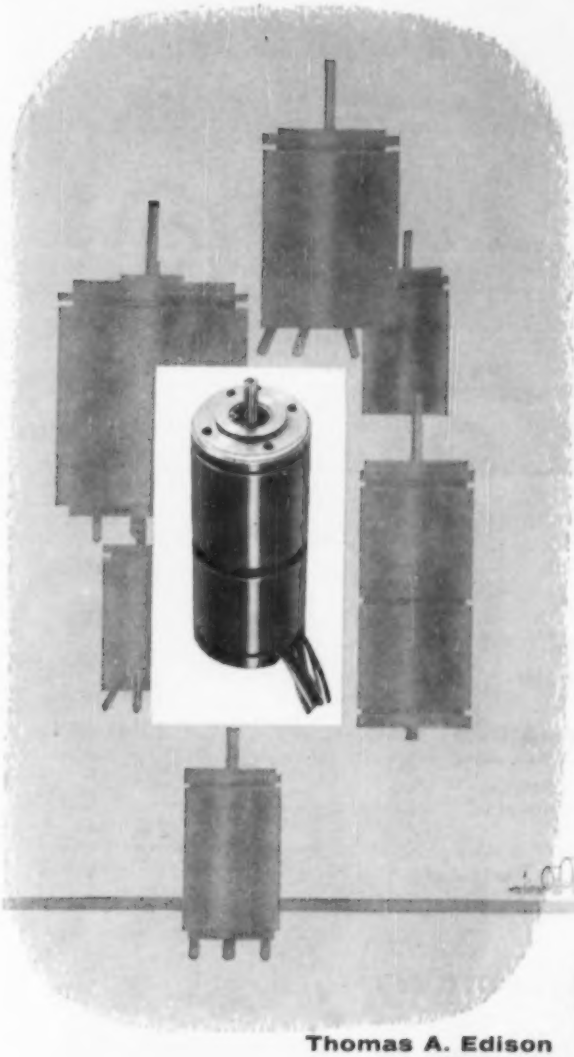
servo systems and components

The Edison Instrument Division is now offering design engineers an extensive line of miniature and subminiature Hi-Temp Servos and Servo Components . . . in addition to a complete facility for custom designed units and servo sub-systems.

Edison's Size 11 Motor Damping Generator for example, was built to such precise tolerances that a leading systems manufacturer was able to make this particular unit do double duty as a tachometer generator. This miniature unit's fast response and large output signal makes it ideal for applications where weight, size and high performance are prime requisites.

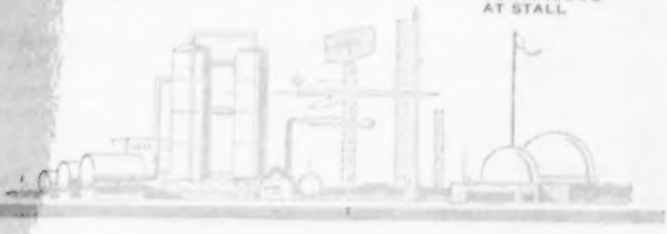
Precision production and rigid quality control inspection have made these "customized" components possible. In addition to these special units, Edison also manufactures an extensive line of standard servo motor and servo motor-generator combinations from size 8 - up, a quality group of synchros, and custom-engineered magnetic heads for flight and ground-based analog computers.

For information about Edison precision Servos and Servo Components, write for Catalog No. 3044 . . . your copy is reserved.



EDISON SERVO MOTOR DAMPING GENERATOR

TYPE OF MOTOR	TWO PHASE SERVO MOTOR-DAMPING GENERATOR
NO LOAD SPEED (MIN. RPM)	5800
STALLED TORQUE (MIN. OZ. IN.)	.60
POWER INPUT TO MOTOR AT STALL (NOM. WATTS/PHASE)	3.5
SPEED AT MAX. POWER OUTPUT (RPM)	3300
TORQUE AT MAX. POWER OUTPUT (OZ. IN.)	.31
THEORETICAL ACCELERATION AT STALL	34,800 RADIANS/SEC.^{2}
TIME CONSTANT	.019 SEC.
POWER INPUT TO GENERATOR AT STALL (NOM. WATTS)	3.5
OUTPUT VOLTS AT 0 RPM (MAX. RMS)	.019
OUTPUT VOLTS PER 1000 RPM (MIN.)	5
PHASE SHIFT (MAX.)	10 DEGREES
DUTY	CONTINUOUS AT STALL



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WRITE FOR:
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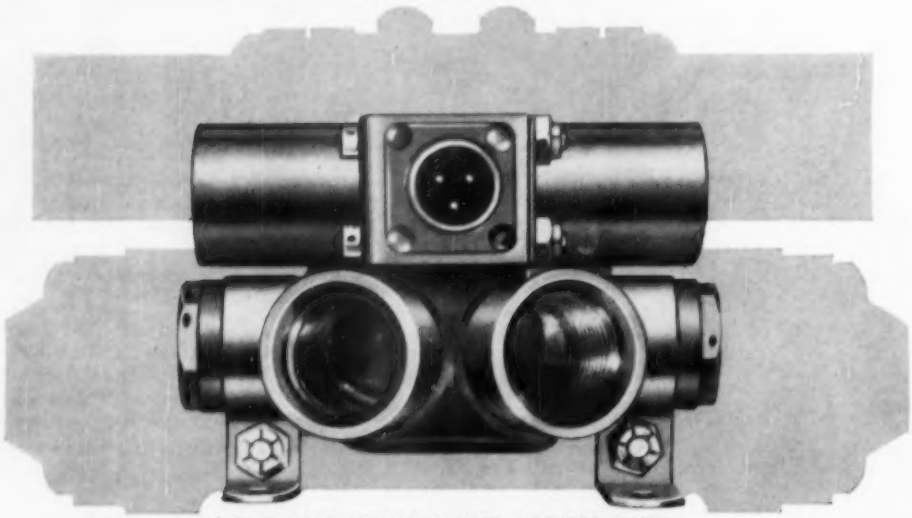
ADEL "DESIGN SIMPLICITY" FOR PERFORMANCE RELIABILITY

New Steel Body, Miniature, Solenoid Operated Directional Control Valves



OLD AND NEW VALVES ACTUAL SIZE

SPECIFICATIONS

Non-Interflow, Low Surge Design Types I & II Sys. (−65°F to +160°F & +275°F) Corrosion Resistant Construction

Operating Pressure Range: 250 to 3000 PSI
Total Pressure Drop: 60 PSI at Rated Flow
Internal Leakage: 10 cc/ Min. Max. at 90°F

Solenoids: Continuous Duty, Single Dry Coil, 18 to 28 V dc operation at −60°F to +275°F
Current Drain: 1 Amp Max. at 28 V dc

Performance and qualification based upon Oil, Specification MIL-O-5606, but suitable for other fluids

Compared with similar valves having aluminum bodies and steel components, these new valves provide: ▶

- 1/5 number of seals
- 1/2 number of parts
- 1/2 space requirements
- 1/2 weight

DESIGNED FOR EXTENSIVE STANDARDIZATION OF PARTS

VARIATIONS

2 and 3 Position, 4 Way
2 and 3 Position, 4 Way with Solenoid Manual Override
3 Position, 4 Way with Piston Manual Override
Line Sizes: ¼, ⅜ and ½ inch Ports per AND 10050

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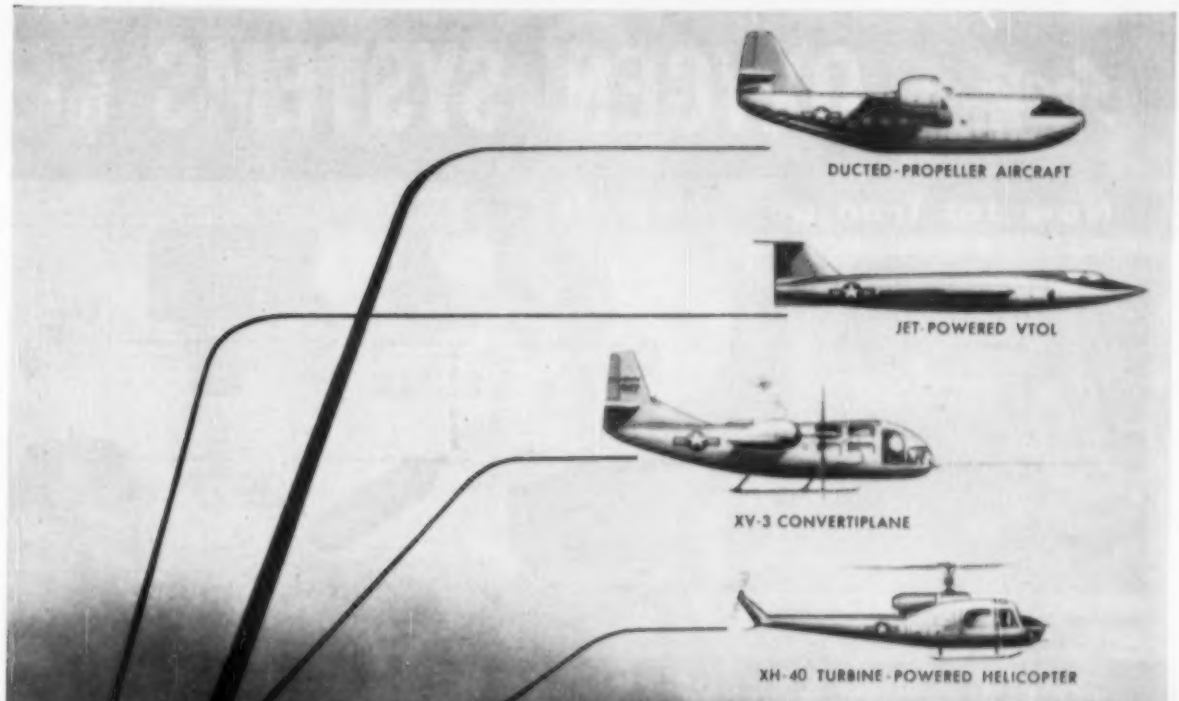

VTOL

...new dimensions of FLIGHT

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BUFFALO N.Y.

BELL AIRCRAFT has kept pace with the need for greater operational mobility and flexibility in both military and commercial aviation by developing four basic types of VTOL (vertical-take-off-and-landing) aircraft.

Studies and development work on a ducted propeller prototype have advanced to a point where this new design concept is fast approaching reality at Bell. The X-14 uses new principles of jet propulsion to take off and land vertically with the airframe in a normal horizontal position. The XV-3 convertiplane takes off like a helicopter, but as its rotors tip forward in flight, it becomes a normal, fixed wing aircraft. The XH-40 turbine-powered helicopter has substantially increased speed and payload and the ability to use a wide range of fuels.

The skillful and imaginative type of research which was the forerunner of these projects is being carried steadily forward at Bell Aircraft in the interest of still further scientific advancements in the commercial and military aircraft of tomorrow.

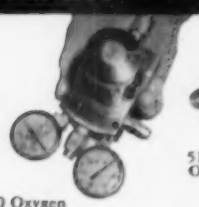
RESEARCH, DEVELOPMENT and PRODUCTION IN THE FIELDS OF: Guided Missiles • Research Aircraft • Servomechanisms • Electronics • Rocket Engines • Electronic Control Devices • Vertical Rising Aircraft

Scott
FOR SAFETY—FOR SERVICE

OXYGEN SYSTEMS for

New Jet Transport Aircraft

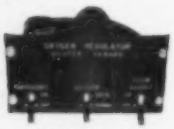
Emergency Passenger Oxygen System and Stewardess Pak



10260 Oxygen Regulator

5120 Universal Oxygen Outlet

Automatic Oxygen Trigger Valve



10400 Diluter-Demand Miniature Panel Regulator

10700 Slow-Opening Cylinder Valve

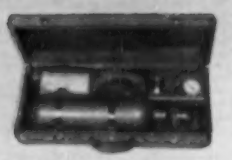
Scottoramic Mask with vision unlimited

Above items are but a few in the Scott Line of Oxygen Systems for the Jet Transport Aircraft. Write for more complete information.

Airline and Executive Aircraft

Scott Oxygen Console for 5

Low-cost, lightweight, Fixed Oxygen System.



AVIOX "Oxygen for 4" in a quality leather carrying case.

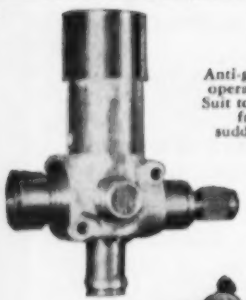
5600 Dual Purpose Oxygen Equipment. Used on major airlines and large executive aircraft. Demand Regulator for Crew, Constant flow for passengers.

Scottoramic Mask optional on all Scott protective breathing equipment.

PLUS

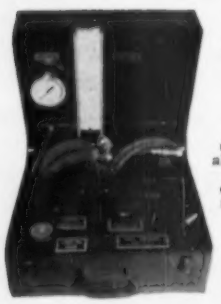
Equipment for small aircraft; Tail wheel assemblies, Control Wheels, Brake Units, Parking Brake valves, Air and Temperature Gauges.

Military High Altitude Aircraft



Anti-gravity "G" Valve operates "G" Pressure Suit to protect jet pilots from effects of sudden acceleration.

A-21 Portable Positive Pressure Demand Unit



Oxygen and Pressure Suit Test Console

Look to Scott for the newest and best in high altitude equipment. Many Scott items now in the design stage will be the standards of tomorrow.

Completely Integrated Survival Kits for high altitude breathing protection and survival after ejection.

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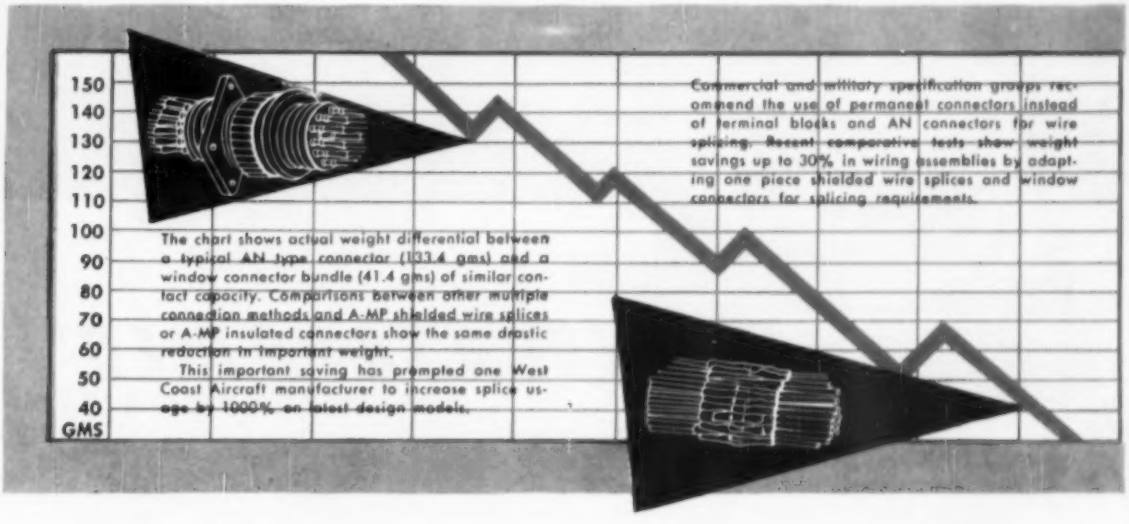
Demands
Weight Relief....



The chart shows actual weight differential between a typical AN type connector (103.4 gms) and a window connector bundle (41.4 gms) of similar contact capacity. Comparisons between other multiple connection methods and A-MP shielded wire splices or A-MP insulated connectors show the same drastic reduction in important weight.

This important saving has prompted one West Coast Aircraft manufacturer to increase splice usage by 1000% on latest design models.

Commercial and military specification groups recommend the use of permanent connectors instead of terminal blocks and AN connectors for wire splicing. Recent comparative tests show weight savings up to 30% in wiring assemblies by adapting one piece shielded wire splices and window connectors for splicing requirements.

ask about amp's Creative Approach TO BETTER WIRING

AMP

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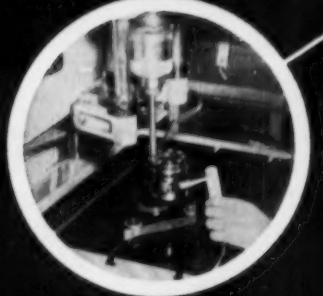
RESEARCH
Continuing research to discover suitable designs, fluids and materials to anticipate future High Temperature requirements.

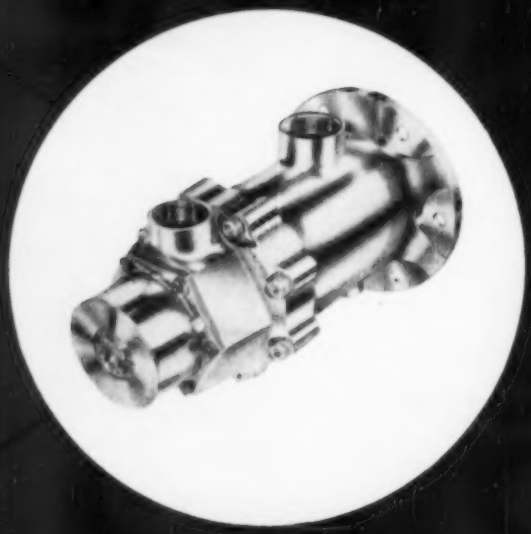
DEVELOPMENT
Laboratory and Test Equipment to pre-prove performance under known or anticipated environments.



PRODUCTION
The most modern manufacturing facilities plus craftsmanship to build "Precision on a Production basis."

400° F

· · · for 150 Hours continuous duty



STRATOPOWER®

..... HYDRAULIC PUMPS

Specified for Elevated Temperatures—

400° F and higher is a reality with advanced STRATOPOWER Aircraft Equipment. Research, design and manufacturing skill applied by STRATOPOWER to years of hydraulic experience combine to produce high temperature equipment that meets your thermal requirements of tomorrow, today. STRATOPOWER development personnel, working on the most advanced high temperature problems, have produced outstanding results. STRATOPOWER Pumps, incorporating these high temperature developments, are available in prototype quantities.

WATERTOWN DIVISION
THE NEW YORK AIR BRAKE COMPANY
STARBUCK AVENUE • WATERTOWN · N. Y.

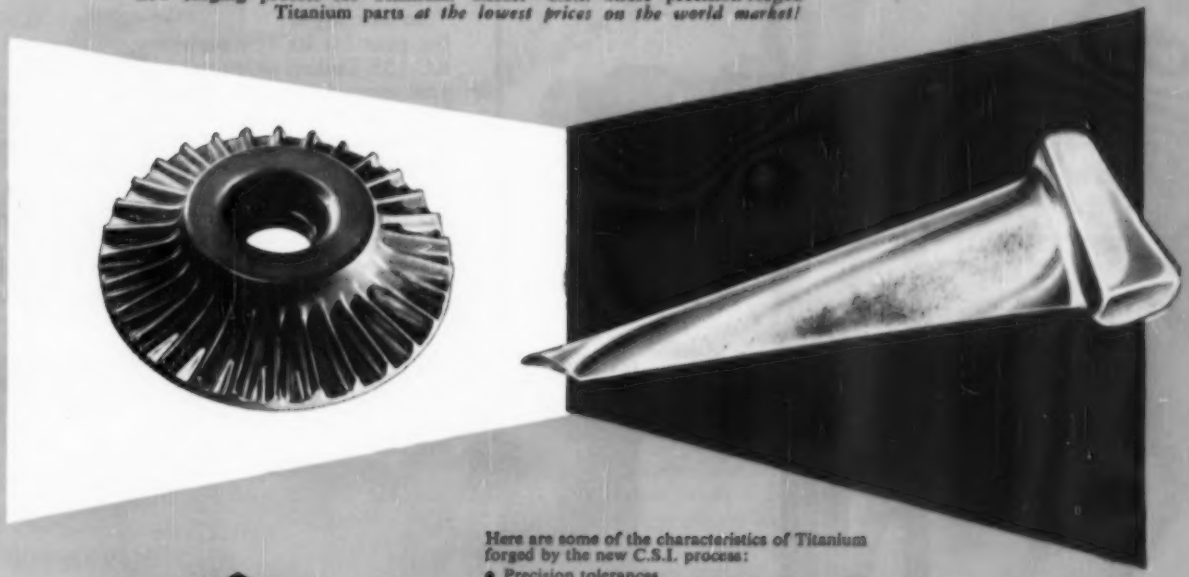
REDUCE YOUR MACHINING COSTS

buy CSI Precision Forgings in

HIGH TEMPERATURE ALLOYS and TITANIUM

C.S.I. precision forging methods greatly reduce the cost of High Temp Alloy and Titanium parts in two important ways. One—tolerances are so close that machining time is reduced to a bare minimum. Two—C.S.I. methods drastically cut the amount of high priced metals required to produce a batch of forgings.

Canadian Steel Improvement has combined these cost-saving factors with an entirely new forging process for Titanium. Result—C.S.I. offers precision-forged Titanium parts *at the lowest prices on the world market!*



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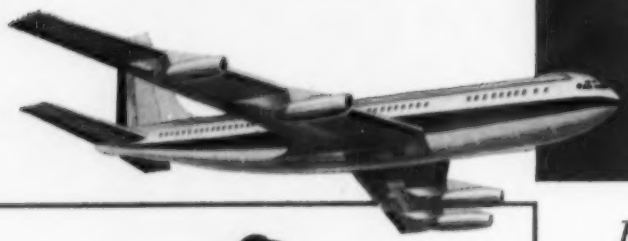

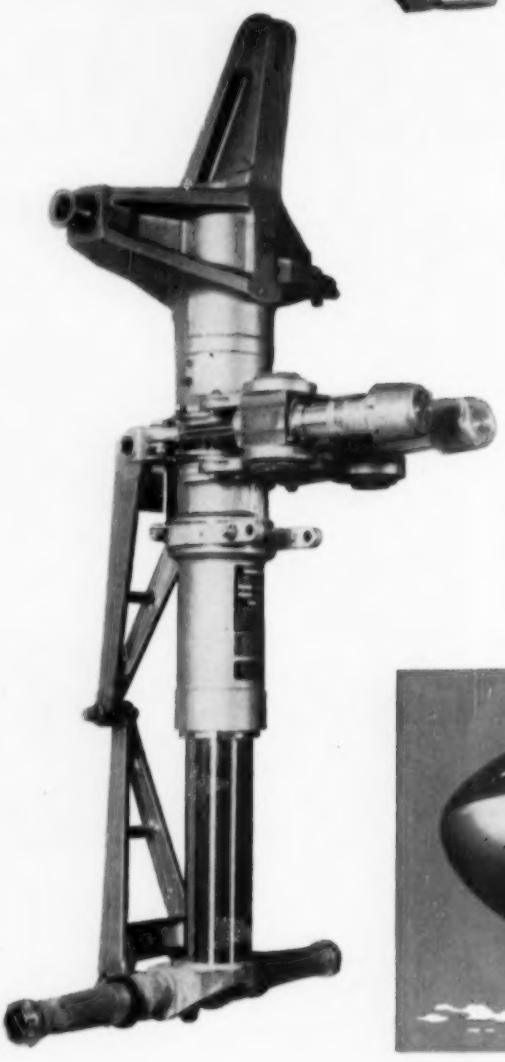

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America's first great jet transports, the 707 Stratoliner and the Intercontinental will provide new luxury, distance-devouring speed and unimagined smoothness of takeoff, flight and landing. Their military counterpart, the KC-135 Tanker, will make possible global operation of another great *BOEING* aircraft, the B-52 jet bomber. These airplanes represent another outstanding *BOEING* contribution to aviation.

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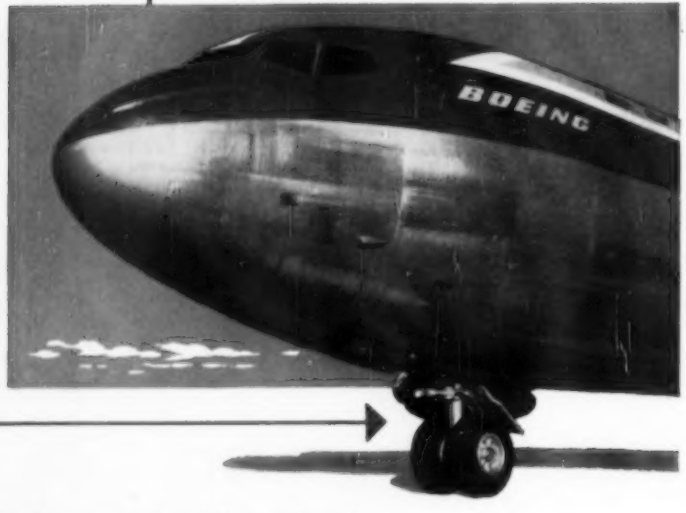

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May 13, 1957

AVIATION WEEK

Vol. 66, No. 19

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New York 36—330 W. 42nd St., Phone: LOngacre 4-3000 (Night LO 4-3035)
Washington 4, D.C.—National Press Bldg., Phones: NAtional 8-3414, REpublic 7-6630
Los Angeles 17—1125 West Sixth St., Phone: MAdison 6-9351
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PUBLISHER.....Robert W. Martin, Jr.
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MANAGING EDITOR.....Alpheus W. Jessup
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COVER: Army's surface-to-surface missile Lacrosse is fired at the White Sands Proving Ground. Missile, developed by Cornell Aeronautical Laboratory under Army contract, is in production at the Martin Co.'s Orlando, Fla., plant. Designed for battlefield use as field artillery, missile uses solid propellant, simple truckbed launcher. It can answer call for fire as quickly as 105 mm. howitzer. Army is training Marine Corps batteries.

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FENWAL UNITS WATCH POTENTIAL HOTSPOTS

Quick, Accurate Units Advance Aircraft Safety

ASHLAND, MASS. — Over-heat protection and temperature control in aircraft have been given a big boost by Fenwal engineers here. They've produced a broad line of extremely accurate and reliable temperature detectors and controls for aircraft.

Based on the unique THERMOSWITCH® principle, the units provide unfailing operation and exact repeatability. This principle is differential expansion wherein the activating control element is a single-metal shell. This single metal shell expands or contracts with temperature changes, making or breaking the totally enclosed electrical contact.

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The line embodies heater controls, cooling effect detectors, differential thermostats, baggage compartment over-heat detectors and midget and miniature controls for tight-spot installations.

All are extremely light and compact.

For details on any or all, write to **Fenwal Incorporated, Aviation Products Division, 126 Pleasant St., Ashland, Massachusetts.**

Fenwal

CONTROLS TEMPERATURE ...PRECISELY

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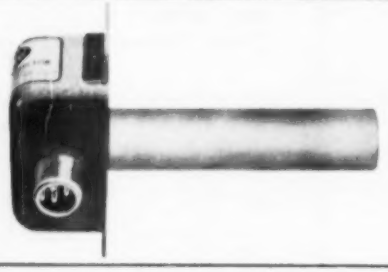
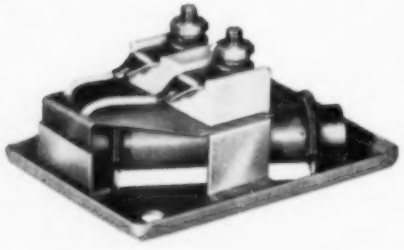
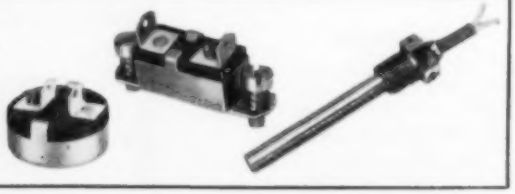


COOLING EFFECT DETECTORS — Functions in same manner as equipment it protects, to sense effect of cooling air.



HEATER CONTROLS, BAGGAGE COMPARTMENT FIRE DETECTORS, DIFFERENTIAL THERMOSTATS — Each uses the THERMOSWITCH unit principle, meaning that each fulfills its special function aboard aircraft with unmatched accuracy and quickness of response. All such units, regardless of function, are light, compact, and hermetically-sealed in stainless steel.



MIDGETS AND MINIATURES — THERMOSWITCH units for tight spots lose none of their reliability when reduced to sugar-cube and cigarette size. Ideal for temperature sensing in compact electronic equipment.

EDITORIAL

Airlines Face Financial Squeeze

The air transport industry is facing one of its most serious financial crises at a time when it is preparing to offer one of its most appealing improvements in service to the traveling public. The gathering financial storm is assuming serious proportions at the very time that most airlines are well into a program to provide jet powered service that will offer major gains in speed and comfort to the traveling public.

Airline business volume is continuing to grow at a healthy rate. Flying is continuing to attract a larger portion of the total travel market. The problem is that the gain in business volume is being rapidly overtaken by rising costs, and the margin of profit is shrinking to a dangerously low level. The details of this squeeze of rising costs against total revenues are detailed by AVIATION WEEK's transport editor L. L. Doty on page 39.

High Costs, Tight Money

There are three principle areas in which costs are rising where airline management has little control over increases. The major area involves new equipment. The airlines have already invested about $2.6 billion in new gas turbine powered equipment. This investment is vitally necessary to airline survival in a highly competitive business and will yield an enormous dividend in improved passenger service. But without a solid earning position, the airlines cannot hope to swing the financing necessary to pay for this new equipment. The current tight money market is making reasonable financing harder to come by and financiers are taking an increasingly dim view of investing in an industry where future earnings are uncertain.

The action by Capital Airlines in deferring a substantial portion of its new jet equipment purchases until a better financial foundation is laid under its operations (see p. 39) is typical of the equipment financing problems facing the airlines. No airline can finance this new equipment out of earnings, and no airline can afford not to enter the jet equipment race if it hopes to survive for the next decade.

Other non-controllable costs increases arise from the boost in gas and oil prices and increases in local taxes on these commodities, and the drive of organized labor to push wages upward. These are items over which airline management can exercise little control in the face of national trends.

Dangerous Economies

There are other areas that offer more fertile ground for management cost control, but in the airline business this too can be dangerous if reductions encroach into the areas of passenger service and flight safety. It is obvious that economies affecting passenger service and flight safety will accomplish nothing but further deterioration of the airline position.

We have heard a number of solutions to the profit squeeze problem proposed by airliner managers, some of them sound and some of them unadulterated wishful thinking.

The fare issue is likely to be with us for some time as a major problem. It may be that a basic fare increase is one of the necessary ingredients in a healthy airline financial picture. But we think any sound solution of the fare problem that offers equal dividends to the traveling public as well as the airlines must come from a general revision of the current patchwork fare structure based on the modern economic facts of the air transport industry and not just from adding another hasty patch to an already complicated and creaking tariff system.

Revised Tariffs For Jet Age

Certainly, the jet era of air transport will need a basically revised tariff system to cope with the new problems facing both operators and customers as a result of this technical revolution.

Some operators are inclined to blame their current problems on the rash of new competition on their favorite routes authorized by the Civil Aeronautics Board during the past several years. New competition is seldom welcome to people who have been reaping a financial harvest from a private melon patch. But there is no question that the added element of competition introduced by the CAB has notably improved passenger service and added to public convenience in some areas where these elements were badly needed.

We think that increased competition, while it may temporarily upset some long-standing economics, is a healthy element and will in the long run improve public service and airline traffic for those airlines that are willing to hustle and expand their market. The continued growth of the total air travel market belies the idea entertained by some airline managements that the air traffic volume is a fixed total to be divided among members of an established cartel.

Traffic Control Drain

We also notice a lack of top level airline management interest in one of the most restrictive factors now throttling the healthy growth of air traffic volume. This is the traffic control bottleneck that automatically scoops millions of dollars out of every airline treasury annually. There are some people now in government such as James T. Pyle, Civil Aeronautics Administrator, and Edward P. Curtis, special presidential aviation facilities planning adviser, who are pushing hard to achieve progress on this front, and the Air Transport Assn. operations staff headed by Milton Arnold has long been in the vanguard of this battle. There are many, many things that can be done now to widen the air traffic control bottleneck and stop the unnecessary drain of airline dollars in bad weather. But they cannot be done without the vigorous and continued support of the highest elements of airline management.

Airline managements are going to earn every penny of their salaries during the next five years wrestling with these and other facets of the financial problems facing the air transport industry. Never in the history of this industry have the rewards for successful management been so high nor the penalty for failure so drastic.

—Robert Hotz

the heart of the jet . . .

— DEPENDABLE FORGINGS —

Ever since the beginning of the development of mechanical power, the heart of power producing machinery has been forgings.

The latest development in the field of mechanical power is the aircraft turbo-jet engine. Here again, the important highly stressed components — the turbine wheels and the compressor discs — are forgings and here also more of these forgings are produced by Wyman-Gordon than by any other company.

Entirely new problems, mechanical and metallurgical, are involved in the production of these vital parts — problems which require the maximum in experience, know-how and research facilities. Wyman-Gordon excels in all of these areas and continues today as for nearly 75 years in the forefront of new forging developments.

Seen through the porthole of this compressor disc is the finished forging — an example of the ultimate in quality and precision.

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Henry W. Zimmer, board chairman, Kawneer Co., Niles, Mich. Also: **Irving R. Seely,** executive vice president, and **David S. Miller,** vice president-marketing.

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Martin Elander, a vice president, United Aircraft Products, Inc., Dayton, Ohio.

F. W. McMeen, vice president, Tubing Seal Cap, Inc., San Gabriel, Calif.

Honors and Elections

Col. John Paul Stapp has been selected the first recipient of the Liljencrantz Award for outstanding research into the medical aspects of acceleration and high altitude flight. The Award, established last year by Pfizer Laboratories, will be presented at the annual meeting of the Aero Medical Association in Denver.

Capt. Milton Leigh McCurry and **Capt. Curtis T. Strong, Jr.,** USAF, have received the American Legion Aviators' Post Valor Award. The Aviators' Valor Medal is presented annually to a member of USAF who has distinguished himself by a conspicuous act of valor or courage performed in aerial flight in or out of combat.

Lt. Franklin F. Eckhart, USN pilot, has been awarded the 1957 Flight Test Engineering Fellowship by The Institute of the Aeronautical Sciences. The Fellowship, gift of an anonymous donor, covers two years of study.

INDUSTRY OBSERVER

► Boeing's improved version of the B-52 is scheduled to fly soon and will phase into the production program in larger numbers than originally planned because of the stretchout of earlier B-52 model production to a 15 per month rate. Main advantage of the new B-52 is substantially increased range due to a large wing containing integral fuel tanks and the substitution of the Pratt & Whitney J75 for the J57 engine. Approximately 20% of the vertical tail area has been eliminated with no anticipated control or stability penalty.

► **Infrared-guided Sidewinder air-to-air missile developed by Naval Ordnance Test Station, China Lake, Calif., has an effective range of approximately 3,500 yards at sea level. Contact fuses are at tips of control surfaces just behind the nose; influence fuse takes care of missile condition in which missile is lethal within 35 ft. Control surfaces are stabilized by small bucket-type wheel turning at very high speed.**

► Convair F-106 all-weather interceptor powered by a Pratt & Whitney J75 with afterburner has reached a maximum speed of Mach 1.87 in flight tests at Edwards AFB, Calif.

► **Fiat is developing a fix on the tail structure of its G.91 lightweight fighter entry in the NATO competition to solve the flutter problem that caused structural failure in flight during the prototype test program. The Italian firm received technical assistance from French researchers, who analyzed the stiffness characteristics of the G.91 empennage material, and the National Advisory Committee for Aeronautics which developed the fix in its Langley Laboratory wind tunnels.**

► USAF is now veering back toward the two-man fighter for its all-weather interceptor mission. Main reason is increased airborne radar range that can be obtained from a skilled operator supplementing the pilot's work and because of the unreliability of completely automatic equipment on which the one-man interceptor is dependent to complete its mission. Advantages of carrying a radar operator now appear to heavily outweigh the disadvantages in term of successful mission completion.

► **Navy this year will begin conversion of obsolescent Grumman F9F-6s to serve as jet drones for air-to-air and surface-to-air missile target practice.**

► Air Force has specified Fairchild J44 turbojets for wingtip installation on about 20 Convair T-29C trainers to be assigned to the Air Force Academy at Colorado Springs. J44s would provide improved takeoff and climb performance at the 5,000 ft. altitude of the fields they must use. Addition of two J44s will add an installed weight of 820 lb. and provide an extra 2,000 lb. thrust to supplement the two Pratt & Whitney R2800 piston engines. Convair plans to offer the J44 wingtip installations to airline operators of the Convair-Liner series since it would provide a faster cruising speed than the Viscount turboprop airliner. J44s will cost approximately $20,000 each.

► **Navy's aircraft production program is 91% on schedule with at least part of the slippage due to design and installation changes. Contracts behind their production schedules as of March 1 include Douglas' A3D, A4D-1 and F4D-1; Lockheed's T2V jet trainer, Pratt & Whitney J57-P-43W jet engine, and guidance and control units for Convair's Terrier surface-to-air missile.**

► Marines have developed a tactical airfield fuel dispensing system that can be carried ashore by helicopter. System includes rubberized canvas tank systems, a small pumping station and a pipeline hose system connected to supply ships offshore.

► **Cornell Aeronautical Laboratory is modifying a Weather Bureau CW radar set as a tornado warning device. Tornadoes are charged with electrical activity, and it is believed that an increase in antenna gain will enable the radar set to identify and trace tornado activity.**

HOW THE SILICONES MAN HELPED...

LIGHT UP THE LIFE OF A DOUBLE-DECKED COMMUTER

Greater comfort for commuters . . . and increased efficiency for railroads in these double decked coaches now in service on the Chicago and North Western Railroad. Brighter, roomier, air conditioned . . . and passenger capacity more than doubled. Problem? Greatly increased power demand but no more space for motor generating equipment. Solution? Class H insulation with Silicones.

The engineering staffs of Waukesha Motor Company and Harnischfeger Corporation, cooperating with the C&NW, designed and built a Class H generator using UNION CARBIDE Silicones as the insulating resin. Silicones stand up under temperatures and loads that break down other insulating materials. The result is a unit no larger than those previously used, but supplying sufficient power to meet the new demands *plus* any overload condition.

This is another example of how the UNION CARBIDE Silicones Man has helped solve an "impossible" insulation problem. Silicones permit smaller units for equal jobs . . . or greater capacity for added loads. To obtain more information, write for "Class H Insulation with UNION CARBIDE Silicones." Address Dept. AW-52, Silicones Division, Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

UNION CARBIDE TRADE-MARK SILICONES

The term "Union Carbide" is a trade-mark of UCC.

In Canada: Bakelite Company, Division of Union Carbide Canada Limited, Belleville, Ontario.

Washington Roundup

Gen. Power New SAC Chief

Lt. Gen. Thomas S. Power will take over command of the Strategic Air Command, replacing Gen. Curtis LeMay who has been promoted to USAF vice chief of staff. Gen. Power served under Gen. LeMay as vice commander of SAC from 1948 until appointment to his present post as commander of the Air Research and Development Command in April, 1954.

In another shift of major USAF personnel which began with the selection of Gen. Nathan F. Twining as chairman of the Joint Chiefs of Staff (AW March 18, p. 25), Lt. Gen. Frank Everest will move from his present post as deputy chief of staff for operations to replace Lt. Gen. William Tunner as commander of the U. S. Air Force in Europe. Gen. Tunner, in turn, is expected to succeed Lt. Gen. Joseph Smith as head of the Military Air Transport Service (AW April 15, p. 25).

Fast Hearing For Curtis

The extent of congressional interest in air traffic control is indicated by the fact that hearings on proposals by Edward P. Curtis, special Presidential assistant, for the establishment of an Airways Modernization Board (AW April 8, p. 26) will be held before the full Senate Commerce Committee headed by Sen. Warren Magnuson (D.-Wash.). Hearings are scheduled to begin May 14. Aviation measures are generally first considered by the aviation subcommittee.

The Board to "develop, modify, test and evaluate systems, procedures, facilities and devices" for air navigation and traffic control would be composed of the Secretary of Commerce, the Secretary of Defense, and a Presidential appointee not affiliated with any government agency. A second report by Curtis, recommending reorganization of the functions of Civil Aeronautics Administration and Civil Aeronautics Board, is expected to be submitted to Congress shortly.

For Everest: Belated Bow

USAF has received permission to display the Bomarc and Rascal guided missiles on Armed Forces Day, but the Defense Department has turned down a recommendation that the X-10 research plane be exhibited despite the fact that it has been declassified by the Air Force. Nearest thing to an advance in the continuing effort to tell the public about aeronautical progress: Defense Department has told USAF it has no objection if Lt. Col. Frank K. "Pete" Everest now confirms that he flew in excess of 1,900 mph. in 1956 in the Bell X-2. Almost a year ago, Everest won the Air Force Assn. flight test award for his achievement, but until now he hasn't been allowed to admit that he did it (AW Aug. 6, 1956, p. 454). Since his record, the X-2 was flown more than 2,100 mph. by Capt. Milburn G. Apt, who was killed in the research aircraft (AW Nov. 5, 1956, p. 26).

Newbury Replacement Sought

Defense Department is still searching for a successor to Frank D. Newbury as Assistant Secretary of Defense for Research and Engineering. Defense Secretary Charles E. Wilson says he doesn't think it is very important whether his new aide is a research man or engineer, but he is consulting with Deputy Secretary of Defense Donald A. Quarles. Meanwhile, William M. Holaday, deputy to Newbury, has been named Special Assistant to the Secretary of Defense for Guided Missiles, replacing Eger V. Murphree. Murphree will continue as a part-time consultant.

White House Decision

Look for White House decision in near future on two transpacific air route cases involving Pan American World Airways and Northwest Airlines. In one case, Northwest is seeking a permanent certificate on its Great Circle route, which is opposed by Pan American. In the other, Pan American seeks authority to fly the Great Circle route, a proposal Northwest opposes.

Best guess is that the CAB has recommended permanent certification for Northwest and use of the Great Circle route from California to Tokyo by Pan American. Northwest operates to Tokyo via Portland and Seattle.

Willis Alaska Head?

Leading contender for the presidency of Alaska Airlines to succeed Nelson David is Charles F. Willis, Jr., former assistant to President Eisenhower and now a vice president of W. R. Grace & Co. Resignation of David, who had been president and general manager for Alaska Airlines since 1952, becomes effective on Wednesday.

Half-Measure For Pay Plan

Defense Department's own compromise with the Cordiner Committee recommendations provides military pay raises of $12 to $50 a month for 360,000 enlisted men with special skills. Cost will be about $49 million the first year, and it will not quiet the pending storm over rejection of the committee's expert suggestions (AW May 6, p. 25).

Chairman Ralph J. Cordiner, president of the General Electric Co., says bluntly benefits cannot be achieved by "half-measures." He already has told Defense Secretary Charles E. Wilson that the committee proposals, if adopted, can improve combat capability 15%, save up to $5 billion a year before 1962, cut training accidents and improve the general defense manpower situation.

When Cordiner and the committee were assembled with Wilson in the Pentagon last week, reporters were ushered out of the room as Wilson suggested they might like to ask questions about the program. The bouncer: Assistant Defense Secretary Murray Snyder, former White House press aide now in charge of Pentagon information services.

Budget Cuts

Leading Senators are falling in line with the House drive to make sharp reductions in the Fiscal 1958 budget. Sen. Richard Russell (D.-Ga.), chairman of the Senate Armed Services Committee, says he hopes for a reduction of about $3.5 billion in the Administration's $38 billion proposal. Russell believes the cuts can be largely accomplished by eliminating duplications in weapons development projects. Last year, Russell supported the Senate's $836 million increase in the defense budget over Administration recommendations and $1.3 billion above the House allowance.

Helicopter Group Cautioned on VTOL

Dr. Courtland Perkins tells Helicopter Society to improve helicopter before moving to new fields.

By Claude Witze

Washington—Helicopter industry was advised last week to temper its new interest in VTOL and STOL aircraft and devote more development time, effort and talent to improving the helicopter.

Dr. Courtland D. Perkins, chief scientist of the Air Force, said manufacturers must demonstrate they believe the helicopter is here to stay and do something about its major drawbacks—drag, vibration, instability and high maintenance costs.

In an address before the Honors Night Dinner of the 13th Annual National Forum of the American Helicopter Society, Dr. Perkins told an audience of helicopter builders and designers that he finds evidence that they feel the day of the pure rotary-wing aircraft is about over.

It is not true, he said, that helicopters are about to be replaced by more sophisticated vertical and short takeoff vehicles.

Services Need Helicopter

"There are many operational requirements of the Armed Forces that can be resolved more efficiently by the helicopter and there is no question that the armed forces will continue to use them," Dr. Perkins said.

"The use of the gas turbine combined with a sophisticated program to improve the shortcomings of the helicopter will extend its usefulness along many lines, and I would encourage this society to be very vocal in support of this type of development. . . .

"From the research and development point of view we have a very active program within the armed forces which, combined with a new look at the helicopter itself, will be a firm foundation upon which to expand in the years to come."

Dr. Perkins said helicopter improvements can extend the usefulness of the aircraft into areas where it cannot be used at present.

Speaking only a few hours after the forum concluded a technical session on VTOL design and development, Dr. Perkins acknowledged there is a requirement for this type of aircraft. But, he added, he is critical of the sophisticated VTOL-STOL development program because it does not support "basic improvement in our old friend the helicopter." He added:

"It is unquestionably the poor relation in this business, and I feel its posture would be improved to a large degree by an adequate research and development program focused on its shortcomings, namely, its marginal handling qualities, its relatively poor maintainability and its high vibration level."

He also warned the industry and helicopter engineers that he fears too many of them are becoming excited about the VTOL-STOL program without realizing it is geared to "a rather small real projected procurement program.

"I hope," he added, "all of these advocates of one exotic system or another are not being led too far down the primrose path.

X-13 Cited

In the STOL area, Dr. Perkins paid special attention to the new Ryan X-13 Vertijet (see p. 29). He said USAF anticipates a requirement for a tactical supersonic fighter or fighter-bomber with VTOL capability. But, he declared, the requirement is low in priority and may not be developed for several years due to budget limitations.

Dr. Perkins said the Ryan project has been yielding excellent results and a higher priority may be forced for the VTOL jet fighter if the test program shows promise without excessive cost or complexity.

He also emphasized that the VTOL or STOL requirement is one that must be decided by the armed forces and suggested that the industry "back off a bit" and stop promoting the advantages of different systems.

"I have studies," he said, "that prove that STOL aircraft can takeoff and land over 50 ft. obstacles and perform a mission for half the gross weight of a VTOL aircraft to solve the same mission.

"I also have studies that show that for STOL capability of 500 ft. over the 50 ft. obstacle and less, the gross weight, cost, etc., will be as great for the VTOL.

"They also point out that the best STOL is an overloaded VTOL.

"All of these conclusions are being pressed forward with some heat and the industry is taking sides. . . . I would avoid becoming known as an enthusiast for STOL or VTOL. . . ."

At the society's technical sessions, a combination of VTOL and STOL concepts was urged upon the industry's engineers by another military spokesman.

If possible, the forum was told by Lt. Col. John L. Klingenhagen, an aircraft should be designed to takeoff or land vertically with a light load and have the ability for short takeoff and landing with a heavier load.

Klingenhagen, an Army officer now attached to the office of the Assistant Secretary of Defense for Research and Engineering, said an ad hoc committee of the Technical Advisory Panel on Aeronautics has recommended that the combination of concepts be emphasized in research contracts.

The committee believes the state of the art will permit a VTOL-STOL configuration if something is done about improving the specific weights of turboprop propulsion systems.

"Development of such engines," Klingenhagen said, "probably can be completed soon enough for use in airframes being designed now." He urged that all new designs in the VTOL-STOL field include enough flexibility to

'Convertible' Gas Turbine Engine

Washington—Navy's Bureau of Aeronautics has awarded a several-million-dollar contract for the development of a "convertible" gas turbine engine for use in support aircraft to General Electric Co.

Designated the T64, the engine will have a basic power section to which individual units can be added for making it either a turboprop or a turboshaft installation.

Primary uses for the T64, which will be in the 2,600 hp. class, will be in helicopters, short takeoff and landing aircraft and convertiplanes. Both the turboshaft and turboprop versions have a three-point suspension arrangement and will operate with their axis at horizontal, vertical or any intermediate angle, according to General Electric.

The engine is designed to have a power-to-weight ratio of more than three-to-one and low fuel consumption which GE says will provide significant decreases in the gross weight of helicopters using the unit.

The basic power unit of the T64 will be equipped with a remote reduction gear, helicopter controls and torque meter to become a turboshaft engine. It can be converted to a turboprop by the addition of a propeller reduction gear, propeller brake and interchangeable bolt-on control package.

permit taking advantage of improved power units.

Other advances appear vital to VTOL-STOL development:

• **More research and development** on landing gear problems. Skis and low pressure tires show promise of increasing the utility of aircraft in this class.

• **Elimination of brakes** by a more efficient deceleration device. Possible alternatives are reverse-pitch propellers, jet thrust reversers, drag chutes, rocket-driven spikes, etc.

• **Curtailment of dust,** water or debris thrown into the air by vertical or slanted jets or propellers operating on unprepared fields.

• **Blind** STOL, with equipment contained in the aircraft, so that special ground preparations for landing will not be necessary.

• **Mechanical reliability** with emphasis upon helicopter gear drives, rotor mechanisms and the coupling systems between power plants in STOL aircraft.

Powerplant Needs

Another forum speaker pointed out that the power requirements for STOL operation are so high that the additional power required to provide real VTOL capability is not great.

J. B. Nichols of Hiller Helicopters said that, since both VTOL and STOL aircraft can carry increased loads if they use a runway, "it is obvious that every time a runway is available, it will be used.

"It also is probable that over the life of either aircraft type, more long takeoffs will be made than vertical or short takeoffs."

In an argument favoring the VTOL configuration, Nichols cited the fact that the old autogyro was a successful STOL aircraft and that it was abandoned in favor of the more expensive and complicated helicopter. The helicopter's ability to hover, like the VTOL, is what made it popular.

Drastic revision of U. S. Army's cargo helicopter training program was termed "vital" on the basis of French experience in the Algerian war. In a report to the forum on French operations with the H-21 in actual combat, T. R. Pierpoint and L. J. Geier of Vertol Aircraft Corp. emphasized the importance of practice in rugged mountain terrain.

They said the French now require a qualified H-21 pilot to have an extra 200 hours of experience as co-pilot before he is permitted to take command of a cargo helicopter in combat. Total time, the French have found, is not as important as the ability to fly the helicopter under widely varying conditions. In Algeria, for example, the pilots experience violent thermals, high winds and a wide range of temperatures.

Vertol's experts are of the opinion that the U. S. Army is not giving enough operational training under these conditions. They recommend that helicopter companies be formed at such places as Camp Carson or Lowry AFB, Colo., and that all cargo troop assault helicopter pilots be required to take training there.

They further recommend that a new classification of "limited operational" pilot be established for pilots who lack such experience.

The report says the majority of U. S. pilots, "if subjected to severe mountainous combat operations today, would experience excessive operational losses and would fail to exploit the full potential of their aircraft."

French Experience

The French found operational losses were prohibitive in both Indo-China and Algeria until they revised the rules. Success of their new system is indicated by the fact that in 5,000 flying hours in Algeria there were no operational losses due to pilot error and only two training accidents.

Vertol's observers left Algeria convinced that the helicopter is the only practical vehicle for combat missions in this kind of terrain. Lack of roads makes ground vehicles impractical, even if they are operated on tracks instead of wheels.

More significantly, they reject STOL aircraft entirely as a possible tool in mountainous terrain because there are no level landing areas.

On Algerian missions, the H-21 carries an average of 13 fully-equipped troops, plus a crew of three. The main base is at Setif, and all points in the Army sector are within approximately two and a half hours of helicopter flight time.

In the 5,000 missions flown, 40,000 troops have been carried.

Minor changes have been found necessary in the H-21, such as the installation of a loud speaker system that can be operated by the pilot or the troop commander. Actual order for troops to leave the helicopter must be given by the pilot, who can judge the time and place with full knowledge of the terrain and possibly enemy opposition.

Other Lessons From Algeria

Other major lessons learned in Algeria include:

• **Armament is needed** in assault operations to put down enemy fire. The French provide the co-pilot and a soldier posted at the forward door with guns. U. S. Army is working on an installation that will include twin .50 calibre machine guns, four rocket launchers and a .30 calibre machine gun. The combination is ready for tests in Algeria.

• **Cockpit jump seat** should be provided for the troop commander. This will facilitate their mutual agreement on a landing spot during combat.

• **Troop seats and safety belts** have been abandoned. They require too much room and become entangled with the soldiers' equipment, delaying the landing.

• **Protective armor is not** considered necessary. Pilot and co-pilot wear flak vests, and self-sealing fuel tanks are being installed on the helicopter.

• **Maintenance below the depot level** has required 5.80 man hours per flight hour in Algeria. This compares with the U. S. military average of 7.12 man hours per flight hour.

The difference is attributed to the fact that the French have H-21s with the latest improvements and long-service components.

Vertol H-21 helicopters used to haul supplies to Dewline stations in the Canadian Arctic flew 3,770 hours in 1956 without a single accident, the

New AHS Officers

Washington—Don R. Berlin, (above) president and board chairman of Vertol Aircraft Corp., was elected president of the American Helicopter Society here last week.

Other officers chosen during the Society's 13th Annual Forum include Claude Witze, military editor of Aviation Week, secretary, and Marvin D. Marks, of McDonnell Aircraft, treasurer.

The following regional vice-presidents were elected:

Michael J. Theodore, Sikorsky Aircraft, New England region; William Cobey, Transcendental Aircraft, Mid-East region; Donald M. Thompson, Office of Research and Development, Army Transportation Corps, Southeast region; Lloyd R. Novak, McDonnell Aircraft, Mid-West region; Robert R. Lynn, Bell Helicopter Corp., Southwest region, and Robert J. Sullivan, Aircraft Division of Hughes Tool Co., Western region.

Helicopter Awards

Washington—Capt. Wayne W. Eggert, USAF experimental test pilot, last week was posthumously awarded the American Helicopter Society's highest honor, the Dr. Alexander Klemin Award.

Capt. Eggert, considered the outstanding helicopter test pilot, was killed in a crash at Edwards AFB early this year. In nine years of experimental test work, he had flown more than 20 types of helicopters and accumulated almost 2,800 hours of rotary-wing time.

The society's Kossler Award was presented to Robert Suggs, president of Petroleum Helicopters, Lafayette, Louisiana. Suggs was honored for developing the use of rotary wings in offshore oil exploration and drilling operations.

Two AHS Honorary Fellowships were also awarded. They were given to Jean Ross Howard, assistant to the director of the Helicopter Council of the Aircraft Industries Assn. and one of the few women helicopter pilots, and S. Paul Johnston, director of the Institute of Aeronautical Sciences. Johnston was chosen for his help in the management and development of the society in its early years. The awards were presented at the 13th Annual National Forum.

forum was told by Lt. Col. Oscar N. Tibbetts, commander of USAF's 22nd Helicopter Squadron.

Col. Tibbetts said his squadron has 13 H-21's and operates them at 13,500 lb. maximum gross weight at takeoff. Average trip payload is 1,500 lb. with 1,500 lb. of gas in the tanks. He pointed out that the rugged Arctic climate requires hauling of several hundred pounds of survival gear in addition to an auxiliary power unit on all missions.

USAF has found in the Dew Line operation that there is a definite requirement for a twin-engine helicopter with higher speed and greater payload. The H-21s do some overwater flying without the precaution of flotation gear because there is a payload penalty of 300 lb. when it is carried. The gear could be safely eliminated with twin-engine reliability, Col. Tibbetts said.

Doman Sells LZ-5s, Prepares Production

Danbury, Conn.—Doman Helicopters is negotiating additional financing to develop production capacity needed to fill its recently signed contract with Helicondor de Colombia, Bogota, for 10 LZ-5s. Value of the contract is approximately $2 million including spares.

Helicondor is also Doman sales agency for the LZ-5 in Colombia and Venezuela. Under the terms of the contract, Doman is to deliver its first LZ-5 to Helicondor in four months. To meet this date, the company will probably procure one of its demonstrators.

Doman also hopes to settle current pending negotiations with other prospects, since it estimates that it needs at least double the current orders to develop production tooling properly for efficient output. Doman estimates that from start of production to rollout will take approximately nine months.

Defense Procurement Policies Criticized

Washington—Defense Department's procurement policies and procedures for negotiated contracts—which account for 80% of military business—were criticized as still "deficient," despite some improvements over the past year, in a staff progress report made to the House Appropriations Committee.

Notable deficiencies pointed out by the report were in the development of cost principles, subcontracting relationships, audit guide-lines and the computation of spares and parts requirements.

The report is a follow-on to a report made to the committee last year. (AW March 26, 1956, p. 26). Rep. George Mahon (D., Tex.), chairman of the Appropriations Subcommittee on the Armed Services, said a continuation of the staff investigations over the coming year already has been authorized.

The only advance that has been made in the establishment of cost principles for contract negotiation, the report said, has been "a wide area of continuing discussions."

The report objected that the three military services continue to operate under their differing guide lines on subcontracting policy. Overall Defense Department guidance is needed, the report said.

The report declared that "very little has been accomplished" and "immediate action is necessary" to tighten the procurement-audit relationship and to increase the role of auditors in contract negotiations before final commitments are made.

Air Force was criticized for continuing to use flying hours as the yardstick for its computations on spares and parts requirements, despite the fact that independent studies by the Air Materiel Command and the Rand Corp. showed that the demand for aircraft spares is "highly sporadic and not directly related to either flying hour programs or aircraft inventories."

In the Army, the report said, there is "a lack of intensive review of spares and parts requirements" and that "the primary interest is to obligate funds before the end of the fiscal year."

Other points included:

- **Reviews by General Accounting Office** have had "a very salutary effect" in reducing the loose contract commitments of letters of intent. Continuation of the GAO reviews was urged.
- **There is "discrepancy" between** Navy and Air Force on policies on royalties which requires correction.
- **Significant improvements have been made** over the past year in delineating the production area from the research and development area in negotiated contracts—and lessening the use of production funds for research and development work. This, the staff objected in the 1956 report, enables a contractor with a production contract to obtain an advantage in getting additional production contracts.
- **Good progress has been made** in stabilizing the high turnover rate of procurement personnel and raising their standards of competence through intensive training programs. The staff previously objected that military procurement personnel were at a disadvantage in dealing with the high-powered procurement personnel of contractors.

Jet Version of KB-50 Tested by ARDC

Wright-Patterson AFB, Ohio—A new jet version of the KB-50 tanker is undergoing flight tests at the Wright Air Development Center.

Designated the KB-50J, the aircraft was modified by Hayes Aircraft Corp., of Birmingham, Ala., with the addition of two General Electric J47 jet engines installed in pods between the regular outboard engines and the wing tips. Each engine creates 6,000 lb. thrust.

In addition to permitting use of shorter runways, the added power will speed the tanker during refueling operations with jet fighter aircraft so that the mother plane will not force them to maintain near-stalling speeds.

Igor Sikorsky to Retire As Engineering Manager

Igor I. Sikorsky will retire this month from his post of engineering manager of Sikorsky Aircraft Division of United Aircraft Corp. The 68-year-old helicopter pioneer will be retained by the corporation as a consultant.

HORIZONTAL Vertijet flies low over ground observers after making transition from vertical takeoff for the first time.

X-13 Completes Transition Flight

Edwards AFB, Calif.—USAF and Ryan Aeronautical Co., announced last week that the X-13 Vertijet, jet-propelled VTOL aircraft, has completed a transition flight.

The first full sequence from vertical takeoff, to high speed horizontal flight and back to hovering for a vertical landing was made on April 11 by Peter F. Girard, Ryan's chief engineering test pilot.

Avon Turbojet

No performance figures were released, and spokesmen said they are not important because the X-13 was designed to evaluate the concept and controllability, with no emphasis upon speed or range.

The jet VTOL research plane has been flying at the USAF flight test center here for more than a year. Powered by a Rolls-Royce Avon turbojet engine, it is not a test bed but a full-scale airplane that requires a special ground service trailer for takeoffs and landings.

A single hook mounted under the forward fuselage holds the X-13 in position and engages to hold it on the launching mechanism when it lands. The bed of the trailer is hydraulically lifted to the vertical position to launch or receive the plane, and then it is lowered to transport it in a horizontal position.

The Vertiplane has a jet reaction control system to guide it in hovering and slow flight. It is operated by deflecting the jet engine exhaust and moving the throttle.

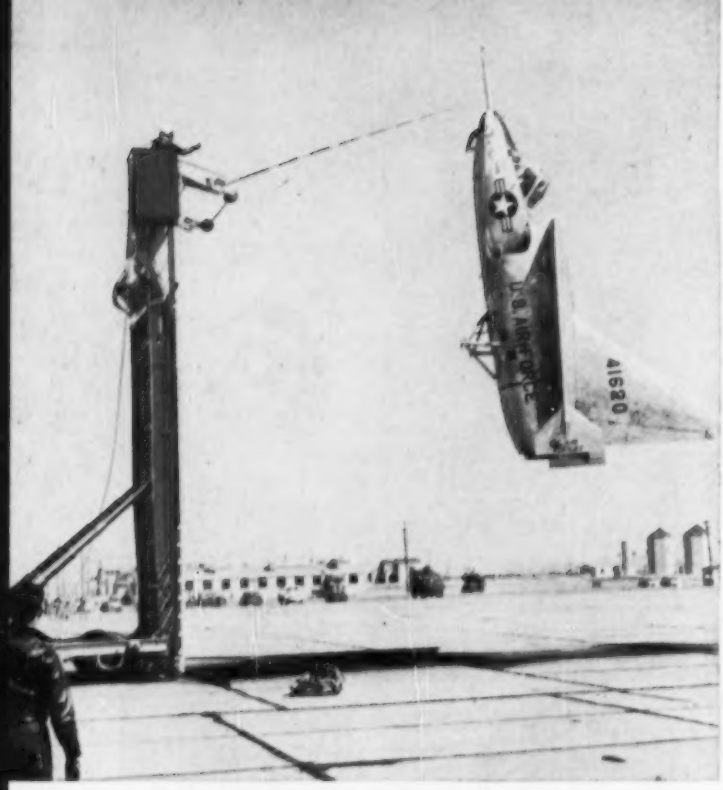
The X-13 also has conventional controls for forward, fast flight operated from a stick and rudder.

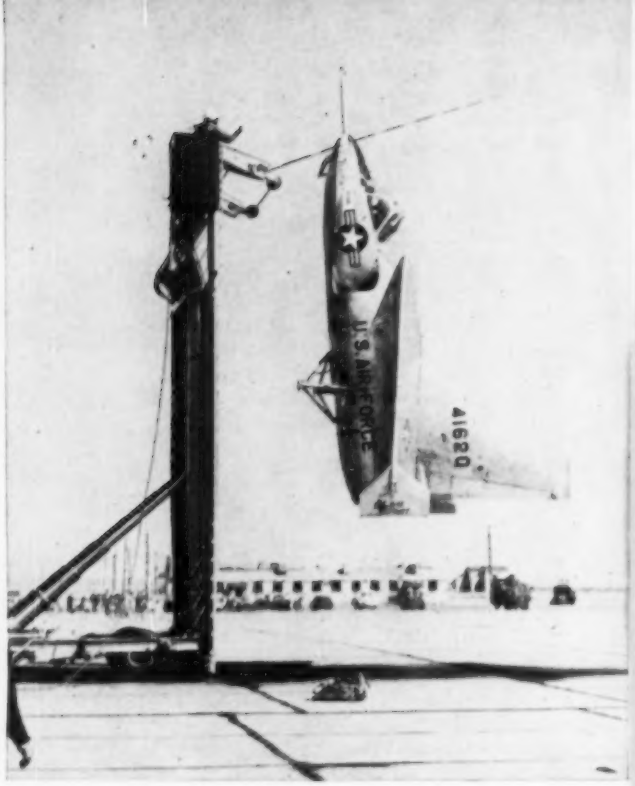
Ryan has been working on the project under a USAF contract since 1953. Prior to that, dating back to 1947, the company had been doing research on the concept for the Navy's Bureau of Aeronautics.

Vertijet Advantages

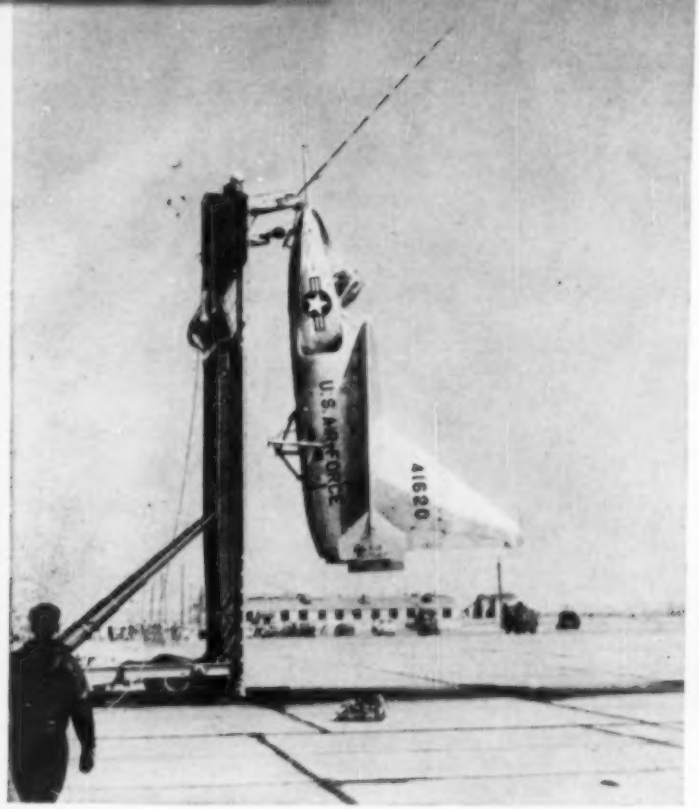
Vertijet's advantages include:

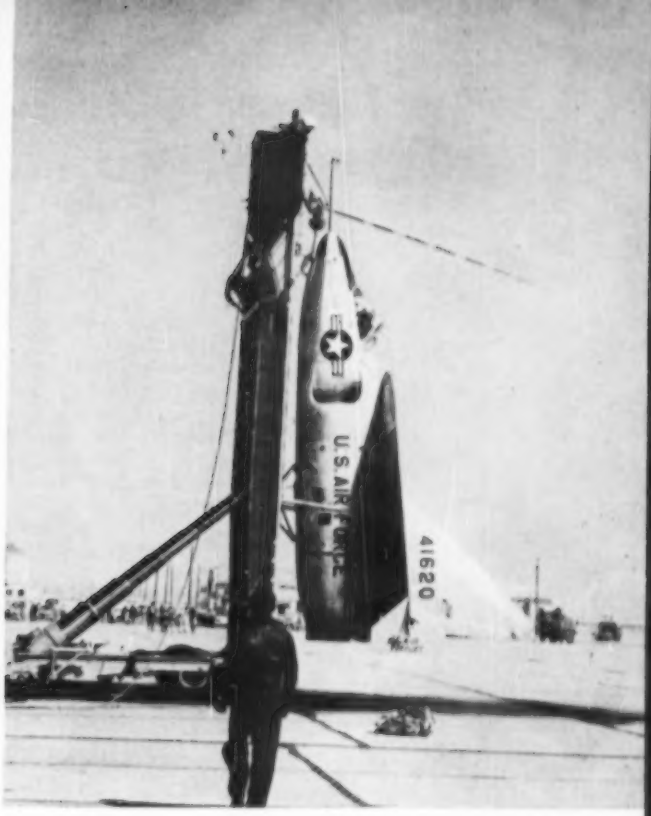
- **It can land and takeoff** in an area half the size of a tennis court, providing new dispersion capability for land-based fighters. At sea, jet VTOL aircraft could be dispersed within a task force, relieving carriers of all defensive fighters if necessary.
- **Lack of conventional landing gear**





TRAILER BED lowers to horizontal position (above) so pilot can exit from the Vertijet. Raising and lowering mechanism is hydraulic.





LANDING, X-13 stands on its tail as it approaches elevated bed of ground service trailer and hooks on (above, left to right). First pictures of the experimental jet VTOL show Vertijet's single hook, just under its nose. The hook engages a cable extended from top of trailer bed. Striped boom serves as guide to pilot in hookup. Jet reaction control system, used to guide the Ryan aircraft in hovering and slow flight, is operated by deflecting exhaust and moving throttle. At lower right, X-13 is hooked on to trailer and ready for lowering forward to a horizontal position.

cuts down on weight and improves the configuration for high-speed performance.

• **New mobility for fighter units** can be realized. The jet VTOL will be as independent of runways as a helicopter.

• **High thrust-to-weight ratio** may result in better combat capability than is possible with conventional jet fighters. It will improve climb, acceleration and maneuverability.

The manufacturer reports that the X-13 is easy to fly and will require little additional pilot training.

The aircraft is approximately 24 ft. long, 15 ft. high and has a wing span of 21 ft. Ryan is working on another VTOL design for USAF and the Navy.

BuAer Research Budget Loses $63 Million on Way to Congress

Washington—Bureau of Aeronautics' research and development Fiscal 1958 budget requests suffered cuts totaling approximately $63 million as they passed through Navy and administration channels before reaching Congress.

Testifying before the House Subcommittee on Appropriations, Rear Adm. William A. Schoech, assistant BuAer chief for research and development, revealed that his department had originally requested $227,706,000 for the fiscal year.

The request, Adm. Schoech said, was first cut by Navy's Research and Development Review Board by almost $49 million—to $178,781,500.

As it moved through the Secretary of Navy's office, it lost another $6 million, dropping to $172,811,500.

Last stop before reaching Congress was the Bureau of the Budget, where the figure was cut to its present level of $165,159,500.

Of this, $111,534,000 is scheduled for research and development work on aircraft and related equipment, down $11,221,800 from Fiscal 1957. The request for guided missiles and related equipment has been increased by almost $4 million, however, to $36,244,000.

Overall, the Navy is asking:

- **$1,932 million for aircraft,** guided missile and related equipment procurement.
- **878 million for operation** and maintenance of aircraft, missiles and supporting shore facilities and equipment.

Major Projects

Aircraft projects of "major significance" now under way, according to Rear Adm. J. S. Russell, chief of the Bureau of Aeronautics, include:

- **All-weather, carrier-based aircraft** for early-warning missions. Although not identified by Adm. Russell, this is probably the Grumman WF-2, a modified version of the S2F anti-submarine aircraft.
- **Land-based,** early-warning aircraft, an improvement of the Lockheed W2V series.
- **All-weather fighter** for operation from carriers as a successor to the Chance Vought F8U. General specifications are now being finalized.
- **Initial design and development** will begin during the fiscal year on a new all-weather fighter weapon system capable of operating at "new dimensions of speed and altitude."
- **Development of a new,** tactical-support, carrier-based aircraft is under way.
- **Long-range, land-based** anti-submarine aircraft containing "significant" improvements in electronics equipment "for the detection, classification and tracking of submarines" is under way as a successor to Lockheed's P2V series.
- **Intensified developments** in high-capacity launching and recovery systems also is planned during the year.

New Anti-Submarine Weapons

Rear Adm. Frederic S. Withington, chief of the Navy's Bureau of Ordnance, told the subcommittee that two aircraft-launched anti-submarine weapons now in advanced stages of development "will defeat the present-day submarine."

Adm. Withington said the bureau is completing the research phase on still another air-launched weapon "which will have far greater effectiveness against the submarine of the future." Similar developments for surface-launched weapons also are under way.

Testimony before the subcommittee brought out that the Bureau of Aeronautics hopes to order approximately twice the number of missiles in Fiscal 1958 as it did in Fiscal '57. Moneywise, the bureau is asking for a total of $236.8 million for increasing the Navy's guided missile capability.

Of this, $211.6 million would go toward providing missiles for fleet training and evaluation; $25.2 million for target drones, specialized missile test and handling equipment and production facilities.

Bureau of Ordnance guided missile requests total $128,341,000—an increase of $13,150,700 over Fiscal 1957. Most of the increase, if granted, will be pumped into the development program of the Polaris intermediate range fleet ballistic missile.

On the other hand, the Ordnance Bureau has decreased support of the Terrier surface-to-air program by approximately $2 million; the Talos surface-to-air missile by $1.5 million; the Sidewinder air-to-air missile by $.5 million.

The program for the Tartar, small shipboard surface-to-air missile, has been increased by $1.2 million; McDonnell's Triton surface-to-surface project by $2.6 million.

Planned funding for Fiscal '58 includes:

- **Philco Sidewinder,** $38 million.
- **Bendix Talos,** $44 million. Adm. Withington reported that the long-range Talos is now being delivered to the Navy for technical evaluation.
- **Convair Tartar,** $32 million. Adm. Withington said development of the Tartar is proceeding on schedule.
- **Convair Terrier,** $59 million.

Adm. Withington also reported the Petrel air-to-surface anti-submarine missile is being phased out and that no further production is planned.

The Navy, which moved full swing into its aircraft modernization program last year, hopes to obtain approximately 78% of its modernity goal during the year. Present figure is 67%. As of Jan. 31, 35.7% of the Navy's fixed-wing aircraft were jets; 58.2% were propeller driven. Helicopters accounted for 5.6%; airships for 0.5%.

Aircraft deliveries during the year, including those contracted for in Fiscal 1957 but not yet delivered, are expected to total 2,123. Of these, 1,220 are provided for in the Fiscal 1958 requests as compared with 1,515 for the Air Force; 470 for the Army (AW Jan. 21, p. 26). Major emphasis will be on the F8U.

Adm. Russell also reported that the Navy has reduced reorder lead time on several aircraft models to between 15 and 18 months and hopes to reduce average procurement lead time from an estimated 19.3 months to 17 months.

Reduced Lead Time

Reducing the reorder lead time, Adm. Russell said, has two advantages:

- **Permits aircraft contractors** to place orders for critical, long lead-time material in advance of receiving their 1959 orders for the related aircraft models since the Navy has increased its request for advance component funding.
- **BuAer can defer requesting** funds for the complete aircraft until next year, which reduces funds required in Fiscal 1958 by an estimated $200 million.

Adm. Russell also told the subcommittee that BuAer plans construction of facilities for testing a new jet engine of very advanced design. Facilities, he said, "were not available for testing engines of these particular characteristics, especially the speed at which the aircraft will fly, and the altitude conditions to which the engine will be subjected." The budget requests contain $13 million for machine tools and related equipment for testing the engine.

Vice Adm. E. W. Clexton, chief of Naval material, testified that the Navy also is "strongly supporting" proposed legislation that would authorize the sale of nonexcess industrial property—including government reserve plants—to private contractors.

Such sales, Adm. Clexton said, "would relieve the Navy of maintenance and administrative burdens and would place these properties on the tax rolls."

Adm. Clexton said the Navy also is making a determined bid to cut down, or eliminate, the number of letter contracts with industry. He said the Navy does not plan to let any letter contracts during the Fiscal '58 program.

Dew Line Could Give Missile Warning

By Katherine Johnsen

Washington—Deputy Defense Secretary Donald A. Quarles says the Air Force can have a defensive network capable of giving a brief warning of a ballistic missile attack by the time the missiles become operationally available between 1962 and 1965.

In testimony before House Appropriations Committee, Secretary Quarles said equipment "now in the works" can be added to the distant early warning system that would give approximately 15 minutes warning of a ballistic missile attack—about half the flight time of the ballistic missile.

With the first detection, Quarles pointed out, the course of a ballistic missile "is quite predictable. . . . You could know fairly accurately what its target area would be."

Brief warning is a requisite, he emphasized, "if we are to mount a positive defense against such missiles in the form of an anti-missile missile."

Quarles, who was USAF Secretary at the time of his testimony, cautioned, however, that deployment of an anti-missile defense system over the country represents "a very large cost" because of the installations involved. He commented that "if we decided an anti-missile system was worth the cost we might be able to do it within several years" after the time long-range ballistic missiles become operational.

Other testimony included:

• **Russia's bison heavy jet bomber** has "substantially shorter range" and "is also believed to be slower in speed" than the B-52, Quarles reported. Although Bison engines have greater thrust than B-52 engines, Gen. Nathan Twining, USAF chief of staff, said that "what we want in a bomber is long range—and our engineers felt that by using the small-thrust engines we would get more economical fuel consumption, and I think we are getting it." Testimony last year that Russia has more heavy jet bombers and is producing these at a faster rate than the U. S. is "incorrect" in the light of additional intelligence, Quarles said. These estimates, Quarles added, do not include the Bear intercontinental turboprop bomber.

• **USAF's planned nuclear-powered aircraft** will be "a valuable bomber," Quarles said in defending the project against some congressional skepticism that it will be a "sitting duck."

• **Maj. Gen. B. A. Schriever,** commander of the Western Development Division, confirmed that the most advanced of USAF's three ballistic missile projects, the intermediate-range Thor, is now being flight tested at Patrick AFB, Fla. (AW April 29, p. 25).

Gen. Schriever indicated that steps will soon be taken to reduce the number of 5,000-mile range missile projects. He said that there will be "very close scrutiny" of the two air-breathing projects—the Snark and the Navaho—this year. Both ballistic missiles will be carried through to initial operational capability, he said, before there is a decision "on which one we should continue in follow-on production."

"Whether or not you eliminate all of the air-breathing missiles in favor of the ballistic missiles," he said, "will depend to some extent on the load-carrying capability of the ballistic missile. It does not have the load-carrying capacity that the air-breathing missiles have, and there are advantages in having the higher yield."

On the nuclear-powered aircraft project, Quarles said the Air Force has abandoned its plan to produce a prototype "flying reactor" without regard to military usefulness "as a luxury we could not afford." This program, he said, would have involved an annual expenditure of approximately $800 million.

The cost between the present and time of achievement of an aircraft with operational capability, Quarles estimated, would have been between $4 and $5 billion. This would indicate that USAF, under this program, anticipated the operational aircraft in five or six years.

Quarles said the new program, involving annual expenditures of approximately $200 million, is expected to produce an operational aircraft "some few years later." He added:

"As we have gotten into designs we have found that the weight of the nuclear propulsion systems were greater than we had thought we could build them, and, as a result, we have progressively boosted the gross takeoff weight of this bomber to a point where it is now very heavy. . . .

"So . . . as we have gotten into this problem, it has become a more difficult problem in an engineering sense and we have now come to the conclusion that we have to back up and take a new hitch on the problem by again attacking fundamentals of materials and reactor designs. . . ."

Quarles said the Air Force has dropped all plans for the present of setting up manufacturing arrangements and will concentrate upon improvement of the propulsion system. Contracts for this with Pratt & Whitney and General Electric Co. will be continued.

B-52 Cutback

Washington—Deputy Defense Secretary Donald A. Quarles has confirmed that USAF cut back its Fiscal 1958 procurement program for the Boeing B-52 by 139 aircraft, a fact reported in Aviation Week on Feb. 18 (p. 21).

In testimony before the House Appropriations Committee released last week, Quarles said the original Air Force budget of $21 billion for the fiscal year proposed procurement of 240 B-52s. The present $17 billion budget approved by the Defense Department, Quarles said, provides for only 101 of the intercontinental bombers. The Secretary added that 269 other combat aircraft and transports also were eliminated by the budget reduction for a total loss of 408.

Missile Investment: $300 Million

Los Angeles—A total of $300 million will have been invested in new industrial facilities for the ballistic missile program, one-third of it provided by contractors, between late 1954 and July of this year, the Air Force disclosed last week.

New plants, machine tools, laboratory and test equipment have been provided for USAF's Titan, Thor and Atlas projects, according to Brig. Gen. Ben I. Funk, deputy director for ballistic missiles for the Air Materiel Command.

There are 17 prime contractors and about 200 first tier subcontractors working on the program, and 35% of all money spent on the ballistic missile program has been dispersed among subcontractors.

AMC's logistical plan for supporting the ballistic missile forces when they are activated will be based on these concepts:

• **System must minimize stock levels** and pipeline time.

• **Support must be direct** from source to user.

• **USAF will make optimum use** of contractor supply and maintenance support until it becomes feasible and more economical to integrate the support into the normal depot system.

• **Administration at the operational level** must be minimized.

Gen. Funk emphasized the importance of USAF's effort to provide interchangeable subsystems in the Atlas, Titan and Thor whenever possible. The multiple approach involves two primes in each sub-system area.

In case of failure or lack of availability, competing developments can

be substituted for each other with ease.

Gen. Funk gave as examples these developments with more than one application:

- **One-half of the North American** booster engine package developed for Atlas is the propulsion unit for Thor.
- **Booster and sustainer engines** being developed by Aerojet for the Titan represent a competing effort.
- **Nose cone for the Titan** competes with the nose cone being developed for Atlas and Thor.
- **Guidance system for Atlas** competes with the one for Titan and Thor. Back of both of these developments are competing efforts in different types of guidance.

If either of the latter succeeds, it could replace those now associated with all three missiles.

Aerojet Delivers Vanguard Engine

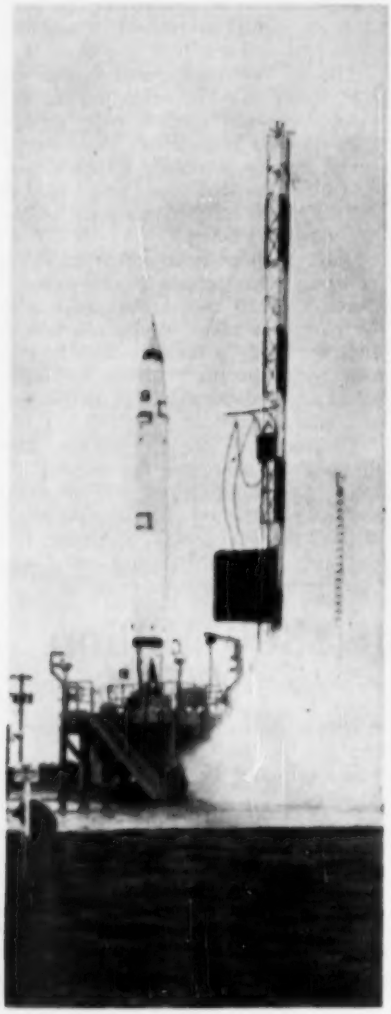
Second-stage liquid-fueled propulsion system for the earth satellite launching vehicle of Project Vanguard has been delivered to the Martin Co. and Navy by Aerojet-General, Azuza, Calif.

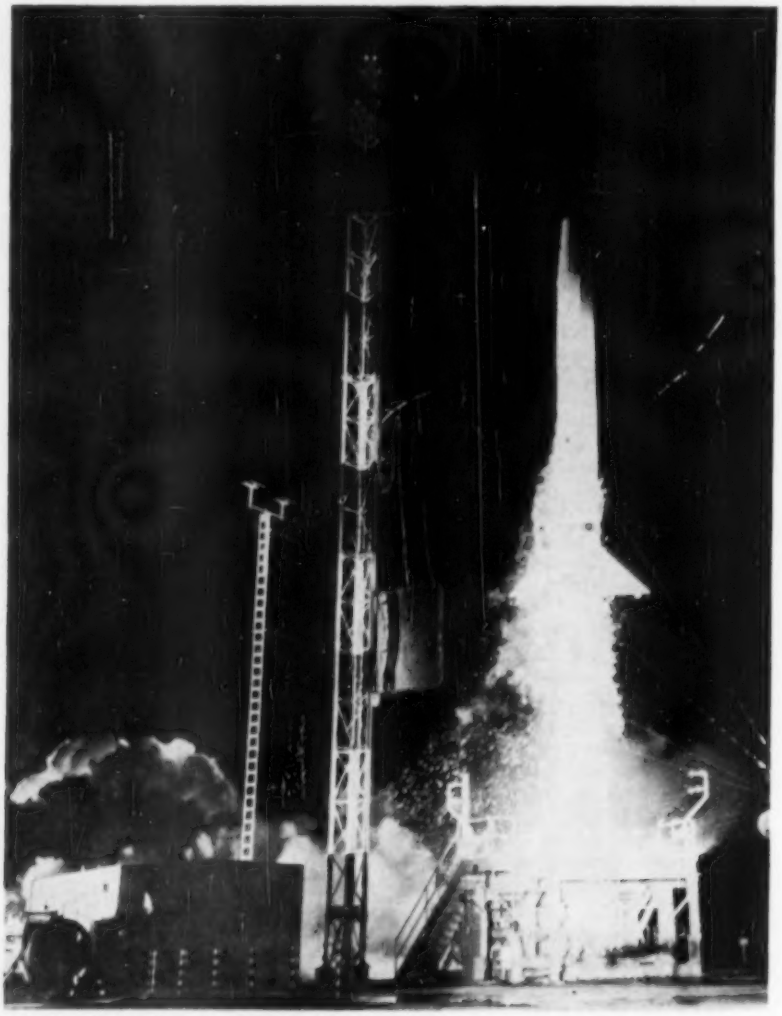
Second-stage engine, as well as the first-stage engine is gimbal-mounted and positioned in pitch and yaw by electro-hydraulic controls. Inertial reference system in the second-stage provides necessary guidance for three periods of flight-first-stage powered flight, second-stage powered flight, and second-stage coasting flight.

After separation from the first-stage at altitude of about 36-mi., second-stage will ignite and proceed under power to a height of about 140 mi. It will then coast forward about 700 mi. in rising to the orbital height of 300 mi., at which altitude the third-stage and attached satellite will be fired.

First stage provides most of the energy to raise the satellite to orbital height and about 15% of the required orbital velocity of 25,000 fps. (18,000 mph.). Second-stage supplies the rest of the energy needed to get the third-stage of the satellite to the required altitude and 32% of orbital velocity.

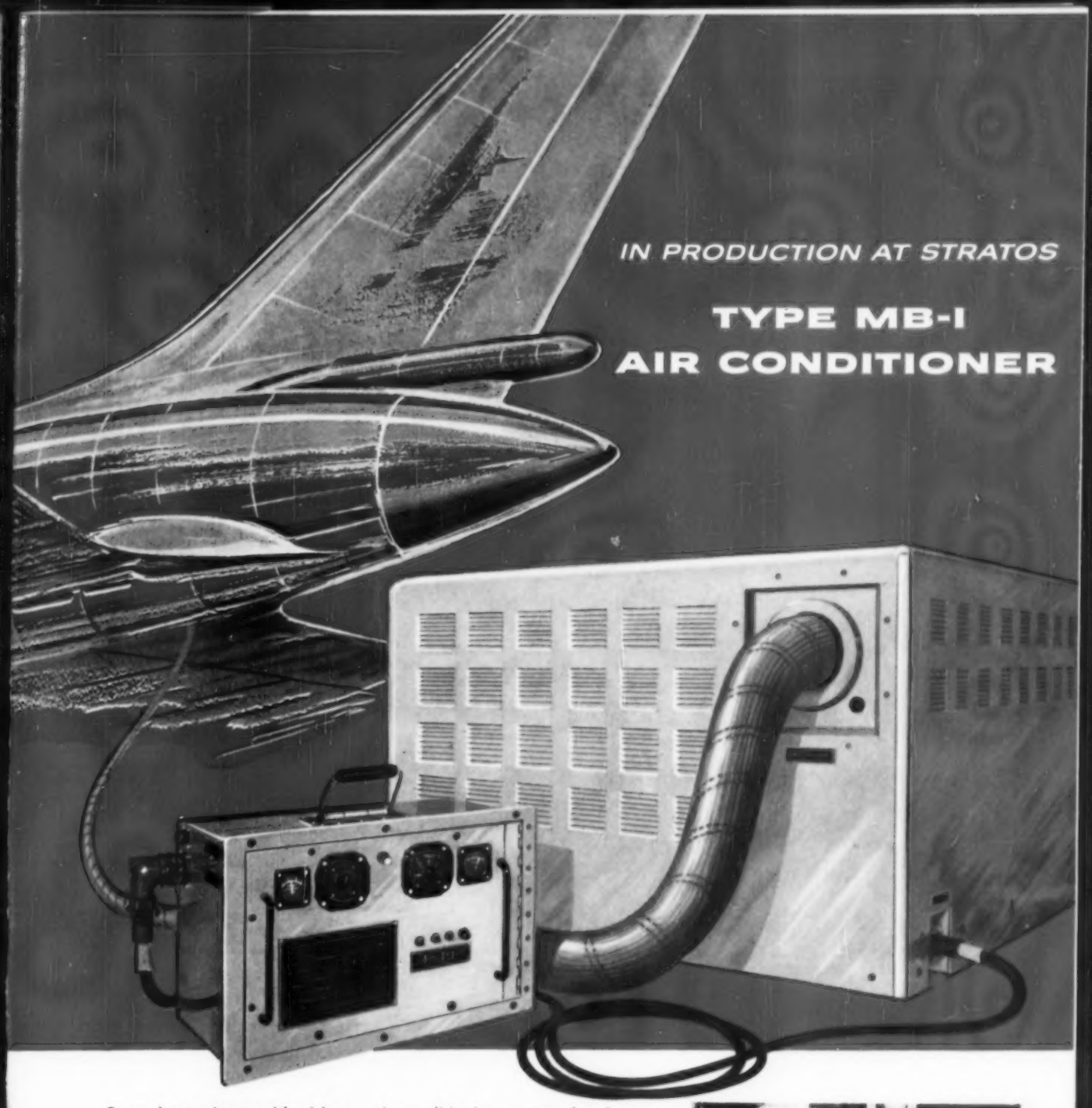
Engine is a warm-helium-pressurized, liquid propellant unit using white fuming nitric acid and unsymmetrical dimethylhydrazine. Tank assembly was fabricated from stainless steel (AW, April 29, p. 33).





Vanguard Vehicle Test, Firing

Second test vehicle in the Vanguard earth satellite program is successfully fired (right) at the USAF Missile Test Center, Patrick AFB, Fla. Viking rocket (left) made by Martin Co. is used for static test prior to firing. Navy said the vehicle reached an altitude of 120 mi., and attained a speed of 3,500 mph. Second stage engine for actual satellite vehicle has been delivered by Aerojet-General Corp. After separation, at about 36 mi. altitude, it will power Vanguard to an altitude of 140 mi., then coast to 300 mi. orbital height.



Stratos' experience with airborne air conditioning systems has been applied to a new, lightweight air conditioner designed for use with gas turbine compressors such as the MA-1A and MA-2 types. Meeting Type MB-1 requirements, the unit is Stratos' Model GEA120-1.

Composed of aircraft quality components, the system is packaged as a compact unit measuring only 48″ x 50″ x 30″. The controls – connected to the package solely by an electrical cable – can be remotely located and, where desired, taken directly into the aircraft.

For additional data on Stratos' line of air conditioning systems, write to:

STRATOS
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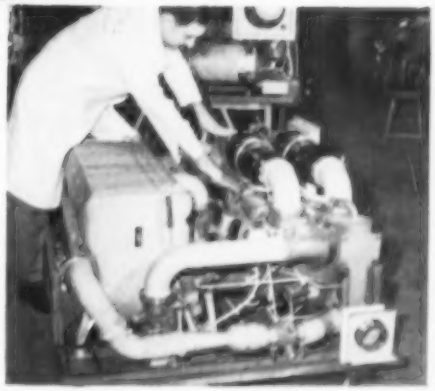
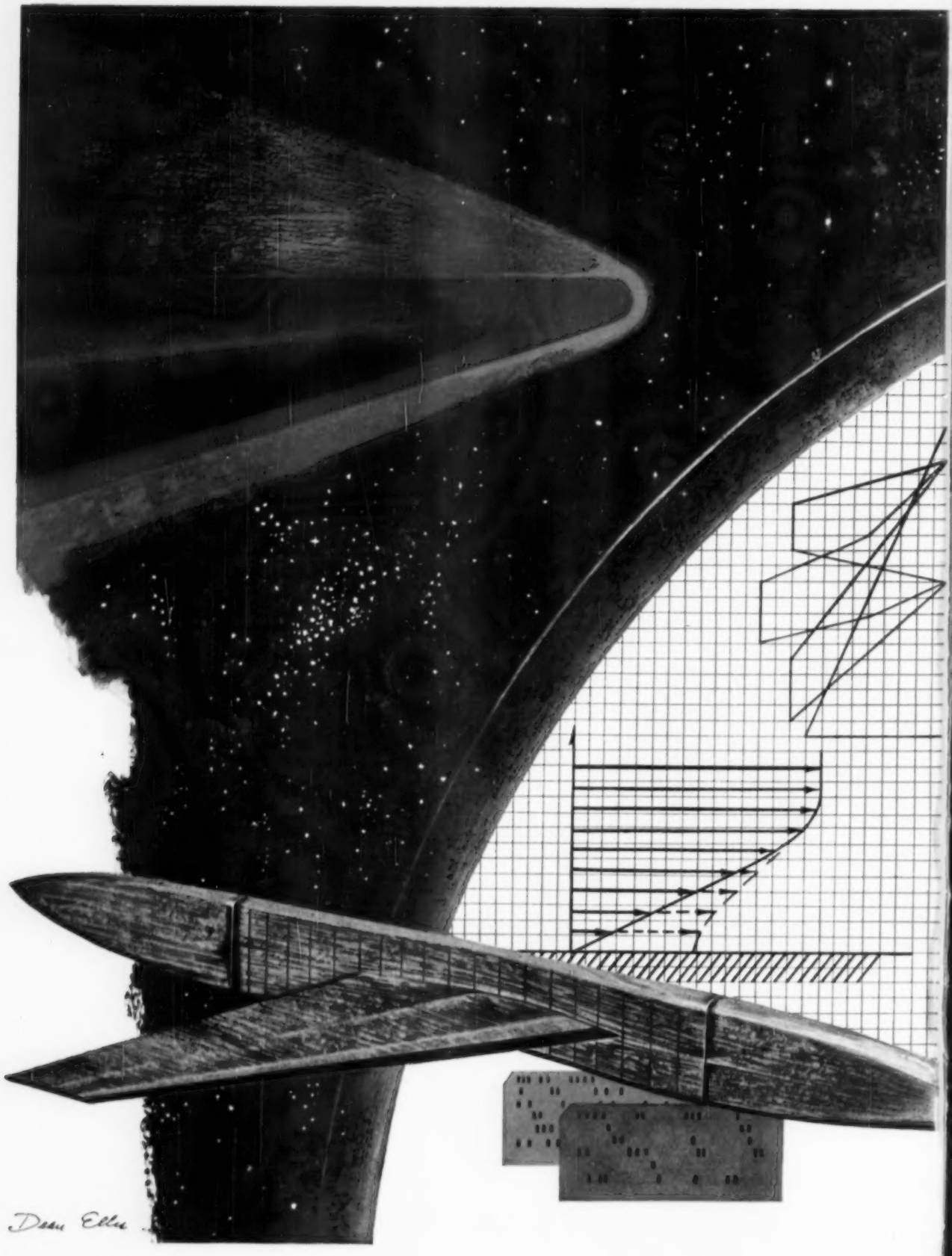
Main Plant: Bay Shore, L. I., N. Y.
Western Branch: 1800 Rosecrans Ave., Manhattan Beach, Calif.



Stratos' Model GEA120-1 air conditioning system being prepared for production test.



Richard A. Scheuing, a Grumman scholarship student, received his M.S. in Aeronautical Engineering from M.I.T. 1948, joined Grumman 1948, and is now Chief of External Aerodynamics in the Research Department.

AERODYNAMIC RESEARCH

by RICHARD A. SCHEUING

At Grumman a considerable amount of work is being carried out on many phases of aerodynamic research. Much effort has been devoted to the analysis of wing-body interaction effects at supersonic speeds; and a method of determining fuselage contours for maximum zero-lift wave drag reduction has been derived and extended to the lifting case. Also being evaluated are the theoretical procedures for computing supersonic drag of complete configurations; additional approaches for improving supersonic and hypersonic lift-to-drag ratios; methods for calculating certain static and dynamic stability derivatives for the complete range of angle of attack at supersonic speeds; and an analysis of the distribution of loads on wings of fairly general planform in nonuniform supersonic flow fields. Most recently a general study of hypersonic flow problems has been completed and a research program concerned with specific problems of this speed range is being initiated.

The intellectual challenge presented by research work and the opportunity to contribute to the advancement of the science of aerodynamics are enhanced at Grumman by the chance to work with and advise men engaged in preliminary design and other development activities. This situation engenders an improved insight into the value of a particular research project and the course it should follow, and helps generate ideas for new projects.

The wind tunnel as a research tool is frequently available in those cases where theoretical analyses require supporting empirical data or where the nature of the project demands its use as a primary source of information. Grumman's extensive high-speed automatic computing facility, a part of the Research Department, is also readily accessible, and is of extreme value in obtaining numerical solutions to problems which previously were considered impractical. Finally, what is possibly the most liberal evening-school scholarship program now available provides ample opportunity to the research engineer to expand his background in and knowledge of his field and allied subjects.

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Designers and builders of the air superiority F11F-1F Tiger, the supersonic F11F-1 Tiger, transonic F9F-8 Cougar jet fighter, F9F-8T Cougar fighter-trainer, F9F-8P Cougar photo-reconnaissance, S2F anti-submarine Tracker, TF Trader carrier-transport, WF-2 early warning Tracer, SA-16B Albatross rescue amphibian, Grumman boats and Aerobilt Truck Bodies.

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Airlines Report More Traffic, Less Profit

Mounting expenses threaten to outstrip revenues; airline profits may shrink by as much as 50%.

By L. L. Doty

Washington—Airline revenues continued to climb during the first three months of 1957, but earnings followed the downward trend set in 1956. Profits may shrink by as much as 50% this year.

Initial reports of domestic trunkline activity during the first quarter indicate that the healthy growth pattern of the industry has not slackened, and airlines can expect a 10 to 12% increase in passenger traffic in 1957.

Mounting expenses, however, are rapidly outstripping revenues, and some officials are predicting substantial losses in 1958 unless some form of relief is provided.

Seven airlines – Braniff, Capital, Delta, Eastern, Northwest, TWA and United—have petitioned the Civil Aeronautics Board for a 6% passenger fare increase as the most logical way of offsetting spiraling costs.

The profit squeeze first became evident when domestic trunkline profits dropped from an all-time high of $63 million in 1955 to $57.4 million in 1956. Local service airlines reported an estimated $923,000 loss in 1956 as compared with $157,000 profit for 1955. At the same time, net profits of the international carriers rose from $13.2 million in 1955 to $20.3 million in 1956.

Prospects for an 8 to 12% increase in passenger traffic each year for the next five years appear to be excellent. But this is substantially below the average 16% gain recorded during the past five years or the 25% increase experienced from 1940 to 1951.

Consumer Spending Up

According to Commerce Department statistics, consumer spending for airline travel has increased more rapidly during the postwar period than any other major product or service category.

Available seat miles appear to be gaining on normal passenger growth, a second major factor causing the profit squeeze. If deliveries of new equipment hold to planned schedule, available seat-miles may increase by as much as 25% in 1957 as compared with a 12% increase in 1956.

Rate of retirement of old equipment as new equipment is received has not been firmly established by most airlines, so it is difficult to measure seat capacity during the next nine months. But this much is known: during 1956, 234 aircraft were added to airline fleets, and lift was increased by 15.6%. A total of 216 new aircraft are scheduled for delivery this year. And at least one airline is running into difficulty in disposing of old equipment at prices it considers favorable.

Profits' Setback

C. R. Smith, American Airlines president, recently pointed out that airline profits have been hit adversely by two policies of the CAB:

- **Failure to increase fares** despite rising costs.
- **Broadening of competition** to cause a greater increase in the total service for sale than in the total traffic increase.

Smith says the CAB policy of increasing the number of airlines on major routes has "thinned out" the total traffic available to any of them. He adds that, in many cases, this situation has reduced load factors and contributed to operating losses on marginal routes.

Other observers fear the increase in competition may result in a capacity increase out of proportion to normal traffic growth. One estimate places the traffic growth necessary to sustain load factors above the break-even point at 35% during 1957 as compared with the predicted 12%.

Competition has been added to 18 of the 25 leading airline travel markets during the past three years, and operating authority has been granted to additional airlines on 14 of the 25 major route segments. Biggest increase has been on the New York-Washington route where nine airlines now operate as compared with three in 1955.

End of Trunk Subsidy?

It is now evident, however, that the CAB policy of broadening competition has strengthened the so-called "regional" carriers to a point that may bring the end of all elements of trunkline subsidy this year for the first time in CAB history.

Continental Airlines recently asked to be removed from subsidy with the inauguration of service over its recently-won Los Angeles-Chicago route on April 28. CAB subsequently issued a show-cause order as a first move toward dropping Continental's subsidy.

Northeast also has been ordered by the CAB to show cause why it should not be removed from subsidy, but the airline has protested it must further reinforce its service over its new New York-Florida route before it can attain self-sufficiency.

Northeast expects to have its full fleet of 10 DC-6Bs in operation by September and to begin service with the first of five Britannia turboprop transports late this year. When the airline moves into a self-sustained operation, no U. S. trunkline will be government subsidized.

Most air lines agree that the 6%

Capital Defers Comet Order

Washington—Capital Airlines has temporarily shelved its plans to take delivery on an additional 15 Vickers Viscount turboprops and 14 jet de Havilland Comets because of a sharp increase in the airline's net loss for the first quarter of 1957.

Capital has notified a group of 24 banks headed by New York's Chase Manhattan that it will not use the credit the banks had granted it to cover the purchase of the new equipment, at least not for the present. De Havilland and Vickers-Armstrongs also have been told of the delay.

Capital's net loss for the period climbed from $1 million in the first quarter of 1956 to $1.9 million for the 1957 period. Gross revenues, however, jumped from $11.8 million to $19.3 million.

A Capital official said the airline is deferring the purchase because it does not want to increase its indebtedness while losses are being incurred. He added that high interest costs of $995,259 and heavy depreciation charges of $2,330,245 on the Viscounts it already owns have contributed to the net loss.

However, he predicted a profit for the year and said the order for the new aircraft probably will be made firm in "two or three months." He said the airline will report a profit for the month of April as compared with a loss in the same month last year.

increase in fares is one essential to strong profit margins but they concede that it is not a complete solution. The system of determining a fair rate of return—based upon original cost less book depreciation—also has been under fire for holding down earnings (AW March 25, p. 44).

According to Stuart Tipton, Air Transport Assn. president, average airline fares have shown an increase of slightly less than 3% since 1938. Bus fares have increased 27%; rail fares are up somewhat less than 50%.

The CAB suspended the airlines' proposal for a 6% increase in March, and hearings on the case are scheduled to be reconvened tomorrow. The suspension is effective for 180 days from March 1. The action will delay the General Passenger Fare Investigation ordered by the CAB primarily as a result of strong congressional pressure for an early reappraisal of airline fares. A House subcommittee headed by Rep. Emanuel Cellar (D.-N.Y.) struggled hard last year for a general rate reduction and virtually forced the fare investigation upon the CAB.

Capital Traffic Gain 65%

During the first three months of the year, Capital showed the most spectacular traffic gain with a 65% increase over the same period last year. The airline attributes the increase to the selling power of its fleet of 59 Viscounts.

American Airlines reported a gross revenue increase for the quarter from $64 million during the first three months of 1956 to $70.7 million. Expenses jumped from $61.2 million to $69.6 million. Profits dwindled from $3.3 million to $1.6 million.

Trans World Airlines reported a first quarter net operating loss of $7,292,000, which, after tax credits of $2.9 million and net operating income credits of $1,167,000 resulted in a net loss of $3,233,000. The 1956 first quarter net loss was $2.6 million.

Operating revenues of the airline followed the general pattern of increase with a climb in revenues from $48.8 million in 1956 to $52.1 million in 1957. Both TWA and Capital have embarked on stringent austerity programs in attempts to regain their profit margins.

Higher rates and the continuing rise in prices are making a strong impact on operating expenses. Several airlines will be faced with renegotiation of union contracts that most likely will lead to further wage hikes.

United Airlines reported an 11% increase in operating expenses during the first three months compared to the same period last year.

The airline's available seat-miles increased 9% during the period, but load factors dipped from 63.6% to 61.1%. Gross revenues were up from $57 million to $60.2 million.

In announcing United's first quarter loss of $1.8 million as compared with a $867,000 profit last year, President W. A. Patterson said the "interim fare increase is well justified by higher costs and the need for adequate earnings during the period of preparation for the jet age."

Money Tight

To date, U.S. carriers are committed to purchase 397 turbojet and turboprop transports at a cost of $2.6 billion. With the tight money situation, airlines that have not already completed financial arrangements may have difficulty in raising capital to meet these commitments, particularly if the earning picture is unattractive to investors.

Northwest Airlines has placed no order for turbine transports thus far, and the $38.5 million available to it for loan through fifteen banks will cover only a portion of the 10 DC-6Bs and 14 DC-7Cs purchased at a cost of $58 million.

Capital has deferred financial arrangements for the purchase of 15 additional Viscounts and 14 Comets pending a decision on the fare increase which it hopes will strengthen its financial position (see box p. 39). The airline purchased its fleet of 60 Viscounts with notes payable in 60 monthly installments from the date of delivery of each aircraft at an interest rate which now stands at 6¼%.

The airline had paid $12,450,000 toward the aircraft as of December, 1956, including proceeds from the sale of piston engine equipment. The high interest rates will have a strong effect upon Capital's earnings, although the airline is forecasting a profit for the year.

The Commerce Department warned in a recent survey of current business that the investment in turbine aircraft is "considerably in excess of total operating revenues from domestic and foreign operations."

Lockheed Sales Peak

Burbank, Calif.—Deliveries of $200 million worth of commercial airliners in 1957 will be the highest in the history of Lockheed Aircraft Corp., board chairman Robert E. Gross reported at the annual meeting of stockholders. Previous commercial high was $131,589,000 in 1955.

Sales and other income of Lockheed and subsidiaries for the three months ended March 31, 1957, totaled $195,479,000, slightly higher than the $187,657,000 for the first quarter of 1956. Military sales were $167,360,000 and commercial sales $28,118,000.

Airlines such as Eastern, United and American have satisfactorily completed financial arrangements in anticipation of equipment purchases. For example, United's commitments for the purchase of aircraft, facilities and equipment totalling $253 million are covered by $120 million 4% sinking fund debentures sold to Metropolitan Life Insurance, Prudential Insurance and Mutual Life Insurance Co. of New York. Bank loans of up to $30 million are available until December, 1960. These funds will be supplemented by earned capital, including depreciation.

Delta Air Lines has accepted delivery on the last of its eight Convair 440s and expects delivery of the first of 10 DC-7Bs next month. Cost of the DC-7Bs plus eight DC-8 and Convair 880 turbojet transports will require a total outlay of $103 million, against which advance payments of $7,461,000 have been made to date.

Delta, which reports on a June fiscal year basis, showed an increase in operating revenues from $48 million in the nine months ending March 31, 1956, to $57 million for the same period of 1957.

Expenses climbed from $42.6 million to $53.4 million and the net income plummeted from $3.6 to $1.5 million.

Northwest Airlines reported an increase in expenses to $18.1 million for the first quarter of 1957 as compared with $15.5 million during the same period of 1956. Revenues were up from $16.2 million to $16.8 million and the net loss for the period rose slightly from $433,000 to $467,000.

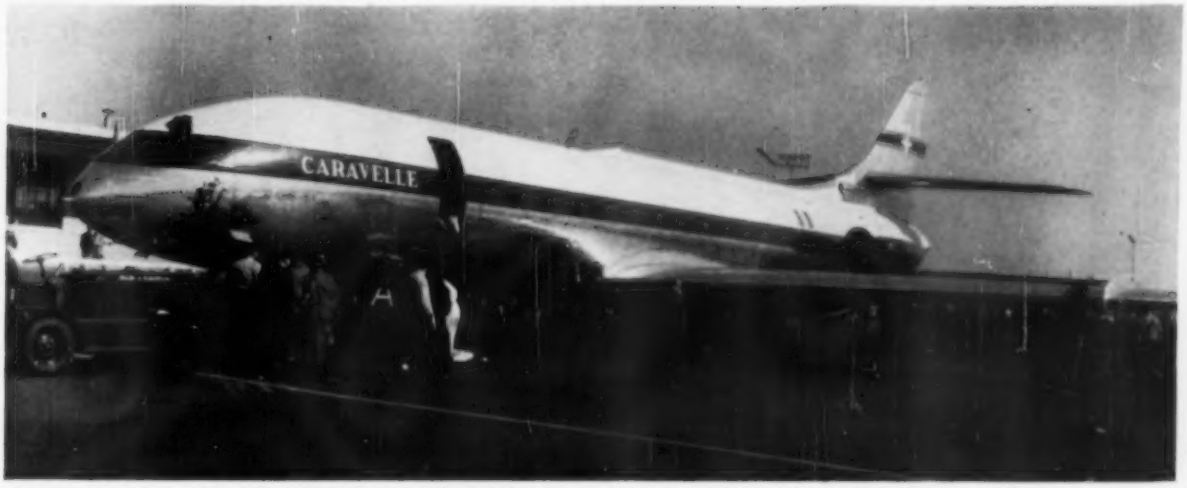
Continental Reverses Trend

Continental's first quarter experience reversed the general industry trend. Net profit for the period was up 103%, from $104,000 in 1956 to $213,000 in 1957. Passenger revenues climbed 11.5%, but expenses were held to a 6% increase.

Subsidy for the airline during the three-month period declined from $340,000 to $155,000.

Western Airlines is covering its $48 million equipment expansion program through the sale of unsecured long-term notes to the Prudential Insurance Co. in the amount of $12 million at 4½%. Last June, the airline publicly offered $5 million in 4¼% convertible debentures due in 1971. Proceeds were used to retire an existing bank loan that permitted the airline to obtain an unsecured long-term bank loan at 4%.

Balance of funds for most airlines beyond long-term loans will be derived from equipment sales, retained earnings and cash throw-off from depreciation. The latter may reach an amount somewhere between $700 and $800 million. This would indicate an additional capital requirement of close to $1 billion.



CARAVELLE is surrounded by crowd after arrival at Idlewild airport at New York, its second North American stop.

Caravelle Finds U. S., Brazilian Buyers

New York–Sud Aviation's American sales campaign for its twin jet Caravelle transport is already beginning to pay off with the first orders clinched in both North and South America.

Varig, a Brazilian international airline, will probably order five Caravelles for use on its South American routes to complement a trio of Boeing 707s planned for its international route to New York. Sud also has an order for three Caravelles from a West Coast airline.

Varig's decision to purchase the Caravelle will mean that the Brazilian airline has shelved earlier plans to buy eight Vickers Viscount turboprop airliners. After recent demonstrations of the Caravelle in Brazil, including a South Atlantic crossing from Dakar in Africa to Recife, Ruben M. Berta, Varig president, told AVIATION WEEK:

"The Caravelle is to the Viscount what the Viscount is to the Convair."

1960 Delivery

Berta said he had been promised 1960 delivery for the Caravelle and added that financing the $10 million purchase would pose no problem with arrangements being handled in Europe.

The Caravelle is ideally suited to Varig's Brazilian routes, which average between 800 and 1,100 nautical miles, Berta said.

Study of Caravelle operations over the Varig routes indicated it would cruise at 380 knots with a payload of 20,000 lb. and an operating cost per seat-mile of 1.1 cents.

Air France has ordered 12 Caravelles with first delivery scheduled for the end of 1958 and has an option for 12 more. Initial European service with the Caravelle is scheduled for 1959 over Air France routes from Paris to Athens, Stockholm and North Africa. Air France's five year equipment modernization plan calls for a total of 40 Caravelles.

Miami-New York Flight

Caravelle made its North American debut with a 2 hr., 41 min., nonstop flight from Miami to New York. The Caravelle took off at a gross weight of 90,400 lb. and carried 53 passengers, averaging 418 mph. ground speed against a mean headwind of eight mph. At the termination of this flight, the Caravelle became the first commercial jet transport to land at Idlewild International Airport.

The Caravelle was flown on its American tour by an Air France crew consisting of Lionel Casso and Andre Lesieur, pilots; Paul Come, navigator, and Jacque Bergines and Robert Lacombe, flight engineers. Also aboard were Georges Hereil, president of Sud Aviation, and Henri Lesieur, general representative of Air France in North America.

The American tour is being made with the second Caravelle prototype fitted with an airline interior aimed at demonstrating a high degree of passenger comfort. The Caravelle is certainly the quietest and smoothest jet transport to appear to date. It is much quieter the entire length of the cabin than the Vickers Viscount, De Havilland Comet and Boeing 707. There is some engine noise noticeable on takeoff but during climb the noise vanishes and vibration is imperceptible.

Engine Improvement

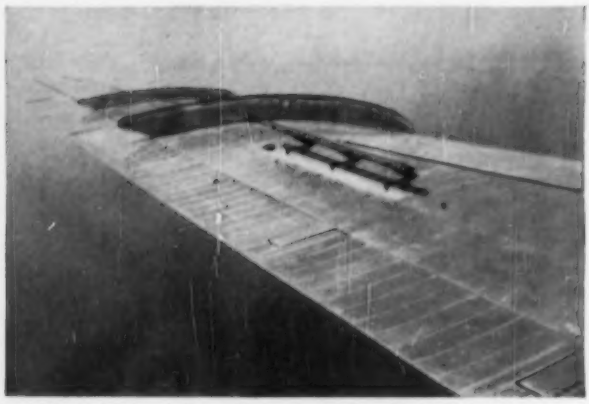
Increased speed, a roomier cockpit, and more baggage space will be the principal improvements incorporated in production versions of the Caravelle.

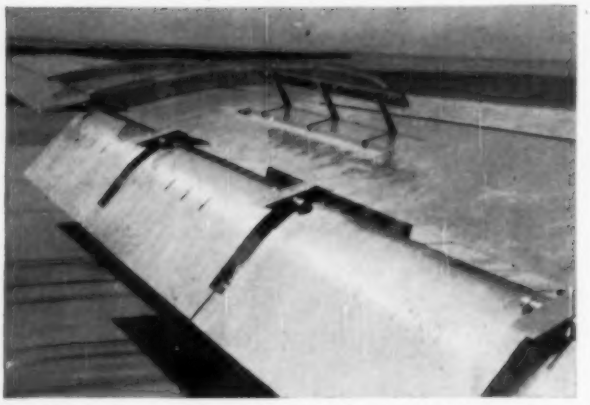
The prototype is flying with Rolls-

Caravelle Specifications

(For Production Models)

Passenger Capacity	64 First Class; 80 Tourist
Speed	500 Mph.
Range	2,200 Miles With 64 Passengers
Maximum Payload	20,000 lb.
Powerplant	Two Rolls-Royce RA. 29 Avons Developing 11,000 lb. Thrust
Fuel Capacity	4,887 gal.
Runway Takeoff Length	5,500 ft.
Runway Landing Length	5,500 ft.
Maximum Takeoff Weight	94,800 lb.
Maximum Landing Weight	90,400 lb.
Wing Span	112 ft., 6.4 in.
Over-All Length	104 ft., 10 in.
Cruising Altitude	20,000 to 40,000 ft.





SPEED BRAKES of Caravelle are partially opened in letdown over Long Island. Flaps and speed brakes both are extended as Caravelle nears touchdown on runway at Idlewild. Larger speed brake surfaces are on undersides of wings.

Royce RA. 26 Avons rated at 10,000 lb. thrust. Production versions for Air France are scheduled to get 11,000 lb. thrust RA. 29s, while there is strong interest in using either the commercial version of Pratt & Whitney's 11,000-lb. thrust J57 or General Electric CJ-805 (J79) turbojet rated at 12,000 lb. for American deliveries.

Caravelle structure is designed to handle engines up to 12,500 lb. thrust without any major modifications. With 11,000 lb. thrust engines, the Caravelle is scheduled to cruise at 500 mph., with a maximum cruise of 525 mph. obtainable from the maximum engine installation of 12,500 lb. thrust turbojets.

In addition to the possible use of General Electric engines, Sud Aviation has other plans for American operators including manufacture of the transport by Republic Aviation on Long Island under license and establishment of spare stocks at established U.S. commercial overhaul centers.

Comet Nose on Prototype

The nose on the two prototype Caravelles were standard Comet noses sections purchased from de Havilland and spliced onto the French fuselage. Sud has developed new nose with a standard Society of Automotive Engineers' instrument panel that will be incorporated in production models.

In addition to demonstrations for airlines in 17 U.S. cities and five South American centers, Sud is exploring the executive aircraft market, and some interest has been shown by aerial exploration groups in using the Caravelle as a high altitude photo plane.

Medics Hit Industry Attitude

By Russell Hawkes

Denver—Dispute over the aviation industry's attitudes toward rear-facing airline seats and other crash survival techniques was touched off at Aero Medical Association's annual meeting here last week.

Col. John P. Stapp, director of USAF Aero Medical Field Laboratory at Holloman Air Force Base, took the industry to task for debating statistics on the value of aft-facing seats instead of initiating positive action to improve the passenger crash survivability margin by known techniques.

Adding fuel to the flareup of the long-standing controversy, Denver physician Horace E. Campbell proposed a resolution urging Civil Aeronautics Administration to establish aft facing seats as certification requirement for all transport category airplanes.

Dr. Stapp was reported by a local newspaper to have accused the airlines of being negligent of the safety of their passengers. But in a later statement to AVIATION WEEK, he said that his remarks had been misinterpreted and that he had intended to criticize the whole aviation industry for debating the statistics on aft and forward facing seats instead of going to the drawing board and improving passenger survival chances.

He said that the principles of progressive failure with the passenger as the last link in the chain of collapse has not yet been fully exploited.

Seat Loads Less

As evidence, Dr. Stapp cited the fact that ultimate load factors of the fuselage of many current commercial transports are as much as three times higher than the ultimate load factors of the seats installed in them. He said that current passenger restraints with the ultimate load of 92G fail to take advantage of the available strength of the human body and pointed out that in his own laboratory a human subject has withstood a 27G deceleration in a forward facing seat with only a lap belt for restraint. He himself survived 35G in

Dr. Campbell is not a member of the Aero Medical Association but he has served on American Medical Association and Colorado Medical Society committees dealing with automotive deceleration injuries. He was invited to read a technical paper at the annual meeting and his request to submit a proposal to the resolutions committee was accepted. Campbell said his proposal to urge upon CAA a requirement for aft facing seats has the support of Col. Stapp, Col. Harry G. Mosely, Chief of Air Force Flight Safety Research, and Dr. Edward Baldes of the Mayo Clinic.

The resolutions committee, headed by Dr. Ludwig G. Lederer, medical director of Capital Airlines, refused to let the strongly worded resolution reach the floor for general debate by association members. Lederer, who is first vice president of the association, stated the position of the committee when he said that it is not the role of the Aero Medical Association to ask specific actions of government agencies. In place of the Campbell resolution, one was reported out of committee asking the association to set up a study group to weigh the advantages of aft and forward facing seats.

During the conference Dr. Campbell criticized Dr. Lederer as an airline representative about airlines' hesitancy to do anything concrete about installing aft facing seats. He pointed to some British air lines already using aft facing seats as a favorable comparison. Dr. Lederer replied that he has seen nothing that he regards as substantial evidence that the aft facing seat offers an extra margin of survival for the passenger or that it is even the equal of the forward facing seat in this respect.

Col. Stapp pleaded for some positive action of any type aimed at improving the survivability margin.

CAB Official Denies Northeast 'Leak'

Washington—Raymond Sawyer, associate director of the Civil Aeronautics Board's International Division of the Bureau of Air Operations, "categorically" denied under oath that he passed information on an executive CAB decision awarding a New York-Miami route to Northeast Airlines.

Earlier, Laurence Henderson, Washington representative of Fairchild Airplane and Engine Co., had testified before the Senate Permanent Investigating Subcommittee that Sawyer was the "probable source" of a "leak" he received on the decision (AW May 6, p. 42).

At the time, Sawyer was executive director of CAB, and Henderson was Washington representative for Trans American Airlines.

The subcommittee is investigating an alleged "leak" of CAB's secret decision late on the evening of Aug. 2. The decision was not made public until Aug. 10. Northeast stock transactions, however, jumped from 500 shares on Aug. 2 to 24,000 shares on Aug. 3.

The subcommittee's case is that all of this upsurge can be traced to two primary sources:

• **Robert Oliver,** a member of the Washington law firm of Pogue and Neal, which represented Delta Air Lines in the New York-Miami case. Oliver telephoned information of the award to Robert L. Griffith, assistant to the president of Delta late in the evening of Aug. 2. Griffith, in turn, telephoned the information to Robert Snodgrass, Republican national committeeman of Atlanta, Ga., at 8:30 a.m. on Aug. 3. The result was a purchase of sizable block of Northeast stock by Snodgrass and his relatives, and later a snowballing of purchases in Atlanta. Oliver's testimony was that his information of the Board decision came from an "anonymous telephone call."

• **Henderson,** who telephoned information of the decision early on Aug. 3 to Forrester Clark, prominent Boston stock broker, and Hardy Maclay, counsel of Trans American Airlines, both of whom purchased blocks of Northeast stock and provoked another upsurge movement in transactions.

Henderson, Raimond Bowles, New England public relations man briefly employed by Trans American; and Gillis Long, Washington attorney and cousin of Sen. Russell Long (D.-Ala.), at the time were promoting the purchase of the 55% stock in Northeast held by Atlas Corp. Their plan was to have it taken over by local New England interests. They were advancing the plan through Clark who has wide and wealthy connections in the area.

TESTIMONY of Laurence Henderson named Board official as probable source.

DENIAL of Henderson's charge was made to senators by Raymond Sawyer (above).

In affidavits to the subcommittee, Henderson denied that he had any "inside" information whatsoever on the CAB decision. In initial testimony, in public session, he testified that he telephoned Clark and Maclay approximately at noon on Aug. 3 to say that Northeast probably had been awarded the New York-Miami route. He said his information was simply a deduction from the fact that he knew the award decision was imminent and that, during the morning of Aug. 3, he noted a sharp upswing in Northeast trading.

Confronted with a telephone toll receipt that his call to Clark had been placed at 10 a.m., Henderson conceded that his information "must have" come from Sawyer. At this point, it was noted by subcommittee members, only 400 shares of Northeast stock had been purchased—by Oliver—and Henderson admitted that this gave no basis for a deduction that there was an upswing in Northeast stock purchases. In his closing testimony, Henderson said his previous affidavits and testimony had been "inaccurate."

Eastern Hits Mexico Proposal

Washington—Eastern Air Lines last week launched a strong attack against a recommendation that Pan American World Airways receive New York, Washington-Mexico City nonstop authority.

The airline filed 30 pages of exceptions with the Civil Aeronautics Board to CAB Examiner Edward T. Stodola's recommended decision. Both Eastern and Pan American were applicants for the route.

Eastern contended that the examiner departed from the spirit and intent of the recently concluded air transportation agreement between the U.S. and Mexico by recommending Pan American. The recommendation, Eastern said, would give greater consideration to Europe-Mexico traffic than to U.S.-Mexico traffic.

The airline said Stodola's recommendation would subordinate all accepted standards of public convenience and necessity; that it would pre-empt dollars in foreign traffic which does not touch this country rather than develop U.S.-Mexico traffic which the bilateral agreement contemplated, and that the dollar value of the long-haul Mexico-Europe traffic was a factor.

At the same time, Eastern also complained that Pan American is "under indictment" in the CAB's general investigation into Pan American's accounting and reporting practices (AW Mar. 18, p. 37).

Some of Eastern's charges closely follow an expression of an opinion on the floor of the Senate May 1, in which Senator Milton R. Young, (R-N. D.) said Pan American's position should remain status quo pending the outcome of the CAB investigation.

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Infrared Seen as Collision Alarm Hope

By Philip J. Klass

Washington—Airline industry hopes for a self contained (non-cooperative) proximity warning indicator to ease the air collision problem are being focused on infrared.

Although many feasibility questions remain to be answered, an all-out industry effort might produce an infrared PWI, with certain operating limitations, in 12-18 months.

It also appears almost certain that a fully automatic collision avoidance system (ACAS) will require development of an entirely different type of system using techniques which require both parties to a potential collision to be suitably equipped before either can be protected.

Because such a cooperative system must be compatible with both civil and military needs, qualified observers believe that the earliest effective implementation of such ACAS systems is at least five years away.

Unpleasant Conclusions

These are the hard, unpleasant conclusions coming out of a three-day meeting held here last week by the Air Transport Association to discuss new ideas and proposals on the air collision problem. The meeting was attended by 225 people, including representatives from major airlines, nearly 50 avionics manufacturers, four aircraft makers, Air Force, Navy, and several other government agencies.

The ATA meeting heard reports by:

• **Three infrared manufacturers** on possible IR proximity warning systems. These included Farnsworth Electronics, Nevada Air Products and Raytheon. A representative of Aerojet-General, major infrared system producer, discussed IR techniques but did not reveal details on the PWI which his company is considering. Six other IR manufacturers, including Avion, Eastman Kodak, Haller Raymond & Brown, Perkin-Elmer, Santa Barbara Research, and Texas Instruments, also attended.

• **Bendix Radio** on its collision avoidance system study-development contract for USAF's Wright Air Development Center.

• **Boeing Airplane Co.** on its own extensive study of the collision problem and recommendations for a specific cooperative system which it believes will accomplish the job for jetliners like the 707.

Major changes in original airline views on what they would like in PWI and ACAS have resulted from extensive analytical studies of the problem by Bendix Radio, Boeing, Collins Radio, and Hughes Aircraft. These have revealed the extreme accuracy with which bearing and closing rate measurements must be made to assure high probability of detecting potential collisions without frequent false alarms that could be equally disastrous.

Current airline views, which will be set forth later this month in a new ATA memorandum, can be summarized as follows:

• **Proximity warning indicator,** which would automatically alert pilot and tell him where to look for an intruder, could greatly ease the present collision problem but would not fully solve the problem.

• **If speedy relief is to be forthcoming,** PWI must be a self-contained (non-cooperative) system which protects airplane on which it is installed immediately without having to wait for other airspace users to install PWI equipment.

• **All-weather vision is desirable** for a PWI but airlines will accept one whose vision is limited to what the pilot can see when alerted. Additionally the PWI should have at least short-range vision through clouds. (There is growing concern that weather radar, by showing pilots narrow corridors of non-turbulence through a storm, may converge traffic into such corridors and lead to collisions.)

• **Cooperative type system** undoubtedly will be required for fully automatic collision avoidance system. To permit speedy development of any feasible PWI, airlines are willing to forego earlier desire that PWI be capable of growing into an ACAS.

• **Civil and military collision avoidance** systems either must be compatible or else each aircraft must carry both systems.

This would place an impossible size and weight burden on many military aircraft and a serious economic burden on civil aircraft.

To assure compatibility, the civil system design can not be frozen until the military design is fixed, and this could take another two years. The military problem, which Bendix is studying, is extremely difficult since the ACAS must cope with the threat of head-on collision between two Mach 3 aircraft. The Bendix contract calls for them to deliver research models in 12 months, indicating that the freezing of the USAF system design could take 24 months.

Airline representatives at the ATA meeting were more impressed with the potentialities of infrared than with the specific preliminary proposals presented by any of the manufacturers, who were unable to give more than rough estimates of possible infrared PWI system performance.

Security prevented disclosure of the performance of specific military IR systems. Another reason is that the range at which an infrared PWI can reliably detect another aircraft depends upon many factors. These include weather conditions, altitude, aspect angle of the intruder, whether it is a propeller driven or jet aircraft, and other factors determined by the specific aircraft type.

Because most military IR systems are designed for use against jet aircraft, there appears to be limited data on the IR radiation from piston-engine aircraft. Within these limitations, infrared experts made the following qualified predictions about the minimum range of an infrared PWI:

• **More than three miles,** with probability of better than 90% above 10,000 ft. altitude, if weather is good enough for pilot visually to see target at this distance. Prediction came from Richard W. Powell of Aerojet-General.

• **Two to eight miles minimum,** in clear weather and daylight, depending on intruder aspect angle, according to Dr. M. R. Krasno of Raytheon.

• **20 miles minimum,** with 90% probability, above 20,000 ft. in fair weather, according to W. E. Osborne of Nevada Air Products.

Estimates of what such an infrared PWI system might weigh ranged from about 30 to 75 lb., depending upon the system and manufacturer.

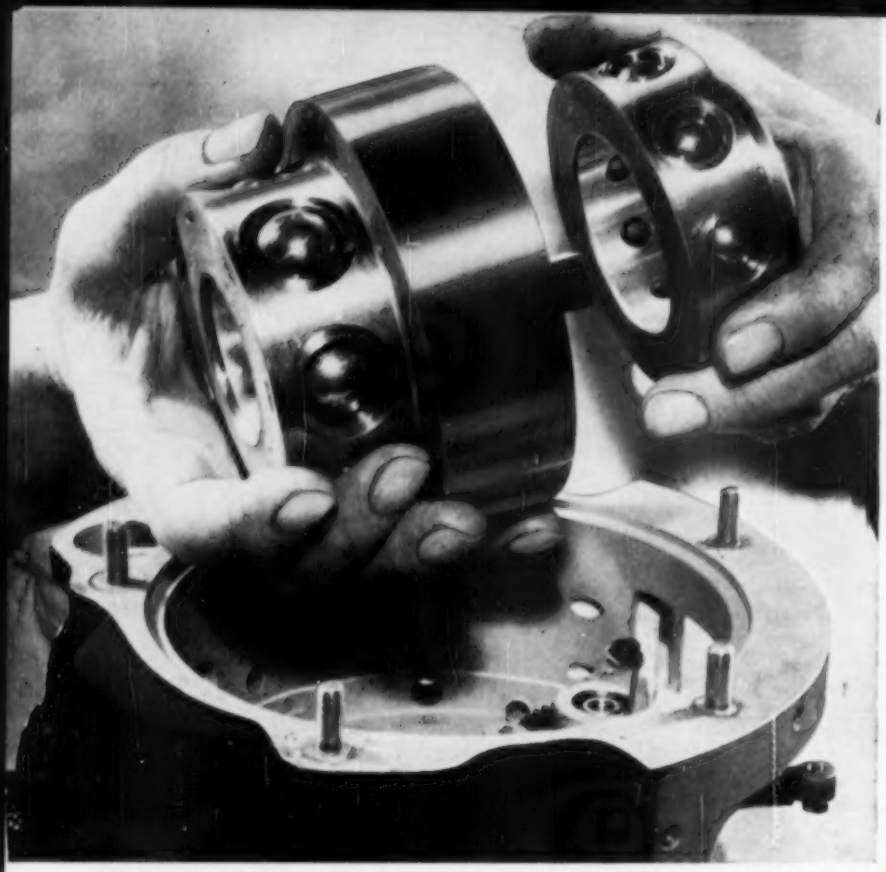
Novel Approach

Perhaps the most novel infrared PWI proposal came from Raytheon's Dr. Krasno. Whereas others proposed to detect the IR radiation from an intruding airplane's engines or jet plume, Raytheon proposed to detect the modulation of background IR radiation in the atmosphere caused by the airplane's propellers or the turbulence produced by its jet engines.

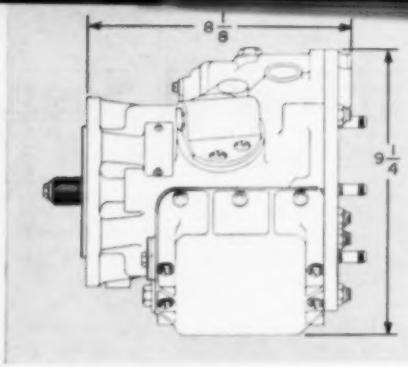
Krasno reported that Raytheon has detected a four-engine airliner in this way at distances where the craft was not visible to the human eye using a four-power telescope. The test was run with very simple experimental equipment.

Another novel aspect of the Raytheon proposal was to supplement IR detection equipment with a closed-circuit TV camera mounted in the tail. When the PWI had detected an intruder and alerted the pilot, he could automatically position the tail-mounted camera for a look at the intruder by pushing a button on the PWI display.

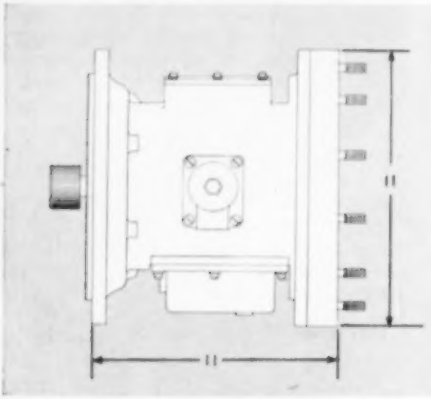
Infrared experts conceded that there



MECHANICALLY SIMPLE ball piston unit shown being assembled in 20 KVA drive replaces conventional cylindrical pistons, connecting rods and bearings. Its use results in a more compact, lighter weight constant speed drive with fewer moving parts.



LIGHTWEIGHT 20 KVA DRIVE weighs 35 lbs. It delivers rated 32 hp over full input speed range of 4300 to 8300 rpm.



COMPACT 40 KVA DRIVE weighs 52 lbs. It delivers 63 hp over full input speed range of 3700 to 8300 rpm.

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COMPACT AND SELF-CONTAINED, a typical 20 KVA drive measures only 8⅛ inches long and 9¼ inches in diameter. It weighs 35 lbs. A typical 40 KVA drive measures 11 inches by 11 inches and weighs 52 lbs.

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might be problems in detecting an intruder coming from the direction of the sun and that stray radiation from ground objects would pose false alarm problems.

One way around these problems, which would also extend the useful range of an infrared PWI, would be to go to a semi-cooperative system where aircraft installed one or two small, low-cost IR beacons, similar to the Grimes flashing lights now used. This might permit an infrared PWI system to have modest range against unequipped aircraft, better range against equipped airplanes.

Another possible semi-cooperative PWI system suggested would use weather and navigation radars now installed on many civil and military aircraft. The installation of radar beacons would permit an intruder in the forward hemisphere to be detected and displayed on radar-equipped aircraft.

A problem arises because airlines use two different radar frequencies (X-band and C-band) and the military use still others. This would require each airplane to carry two or more beacons and would require modification of airline weather radars not now designed for beacon operation. Despite these problems, ATA plans to investigate this possibility.

Boeing Proposal

In revealing the ACAS which Boeing has designed on paper to meet the needs of jetliners like the 707, Edward Sidor emphasized that his company has no intention of building such a system and merely hopes to stimulate avionics industry thinking.

The Boeing ACAS employs an extremely high frequency (35,000 mc.) radar, with one antenna mounted in the nose, the other in the tail. These are synchronized to provide full 360 deg. azimuth surveillance, once every four seconds, over a vertical angle of ±20 deg. from the horizontal. (The nose anti-collision radar antenna would be mounted back-to-back with the weather radar antenna.)

Cooperating aircraft would have to carry small radar beacons similar to those planned for traffic control transponder use but operating at a different frequency. The beacon on an intruding aircraft within the ±20 deg. vertical coverage would be interrogated and reply to the anti-collision radar.

This would provide the ACAS with data on the intruder's azimuth position and its range and closing rate. Use of V-beam antennas in the anti-collision radar would also provide data on the intruder's vertical position. This information would be displayed on a cockpit radar scope indicator and also monitored by a digital computer.

If three successive interrogations showed that intruder bearing was essentially constant and its range decreasing, a collision threat would exist and the computer would flash an alert on the pilot's indicator. It would also show direction and duration of required evasive maneuver.

Hemispheric coverage outside the vertical coverage of the nose-tail antennas would come from omnidirectional antennas mounted atop and underneath the fuselage. These would also interrogate the intruder's beacon, alert the pilot when the intruder came within 5,000 ft., and show the intruder's range and above-below location but not its exact position.

Airline interest in the Boeing system appears to be luke-warm. Although Boeing's William Hamilton said the company has made no size or weight estimates, observers speculated that it might weigh more than 200 lb., cost more than $50,000 per installation.

Furthermore, the range of a 35,000 mc. radar, even with beacons, is seriously reduced in heavy precipitation. Some airline observers believe that Boeing failed to assume sufficiently heavy rainfall.

Airlines Say Jet Noise to Be Cut To Reasonable Level by 1959

By Ford Eastman

Chicago—Airlines say they are confident commercial jet noise can be diverted or reduced to a point where it will be acceptable at municipal airports and adjacent areas by the time the jets begin operation in early 1959. Employment of certain techniques and devices could possibly reduce the noise level below that created by piston engine aircraft.

Latest developments and result of tests made in noise control were outlined at a meeting of the Ground Equipment and Maintenance Facilities Subcommittee of the Air Transport Assn.

Delegates pointed out that the major problem is the need for additional suppression of jet engine noises in the maintenance run-up areas where full power may be applied for short periods of time. Jet engines are scheduled to be equipped with suppressors to reduce noise during normal operation.

Another problem may be the high frequency noise from the engine air intake when running at low speeds such as taxiing to and from airport gate positions. In some cases, exhaust blasts may also create a problem.

The big question, however, is to what extent noise will have to be suppressed in order to prevent annoyance.

When the acceptable noise level is determined at airports and the surrounding areas, then steps will be taken to meet the requirements. Engineers claim that substantially any degree of noise reduction in the operation of jet engines can be obtained. It depends upon the amount of money to be spent for this purpose or the acceptable noise level that can be tolerated.

The two main sources of noise in a jet engine are from the exhaust and intake areas. At high engine speed, most of the noise comes from the exhaust, while at low speed the air intake emits a high frequency noise that may be objectionable at close range.

Various methods have been developed to eliminate both, but the most successful methods of reducing noise also result in a corresponding loss in engine operating efficiency. A compromise is being sought between the cost, size, and weight and inconvenience and an acceptable noise level in the particular area involved.

Other factors also may aid in eliminating noise. Exhaust noise is to a large extent directional, mostly confined to an arc directly behind the pipe. Intervening buildings and terrain will have an insulating effect.

Therefore, if it is possible to conduct run-up tests with exhaust pointed toward sparsely populated areas, it is conceivable that no suppressors would be needed.

Delegates generally believed that, if jets are to be taxied to and from terminal gates under their own power, additional precautions may have to be taken for the protection of passengers at the gate and airline personnel on the ramp. Here—in addition to the high frequency noise—exhaust blasts similar to prop-wash could become a problem at some gates.

Use of barrier fences between gate positions have provided the best answer thus far. A substantial reduction of noise has been achieved, and the blast effect against persons behind the barrier or boarding aircraft at adjacent gate position has been practically eliminated.

The fences are constructed to stand at car-level height and at a slant so that the blast and noise is deflected upward. They are situated on both sides of the gate and extend out onto the apron.

A drawback to this method, however, is that it virtually isolates each gate position, and airline personnel servicing an aircraft at one gate must go around the fence to reach the next.

RCA ANNOUNCES . . . THE

AVQ-60 AIR TRAFFIC CONTROL TRANSPONDER

Designed for airline, business, and military transport use, the AVQ-60 Air Traffic Control Transponder automatically and instantly enables the traffic control radar to locate and positively identify aircraft within its range.

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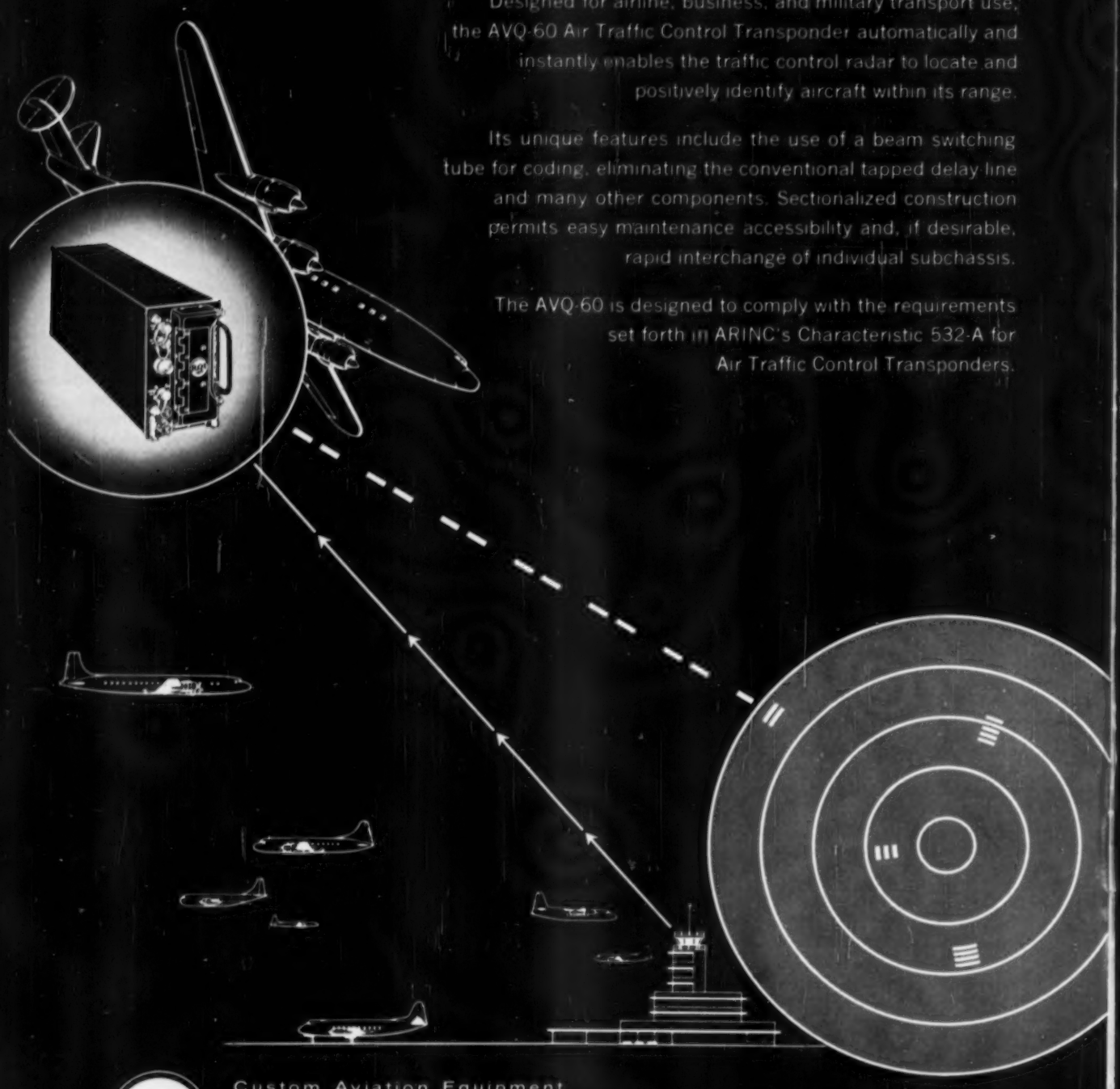
The AVQ-60 is designed to comply with the requirements set forth in ARINC's Characteristic 532-A for Air Traffic Control Transponders.



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SHORTLINES

► **National Airlines** says it cannot operate into Boston next winter without "adequate hangar facilities" at Logan International Airport. Alexander Hardy, National senior vice president, told the Massachusetts legislature that last winter the airline was forced to cancel flights because there were no facilities at Logan for the carrier to overnight or de-ice aircraft. Hardy said National would be willing to enter into a lease for hangar facilities at no cost to taxpayers if the legislature would pass a bill authorizing construction of a hangar.

► **American Airlines and United Air Lines** have begun operation of a mutual teletype exchange at Chicago for simplifying interline reservations. Using the system, an agent sends an interline transfer request to the mutual teletype exchange in Chicago where it is automatically relayed to the communications equipment of the other airline and transmitted to the desired city. Space confirmation is handled in the same manner.

► **Icelandic Airlines** (I. A. L.) increased its scheduled operations between New York and Europe to daily flights on May 11. The new service, leaving New York on Tuesdays, provides a second weekly flight to Glasgow, Scotland, and on to London. Roundtrip tourist fare is $469.20 during the summer season.

► **United Air Lines** has contracted agreements with 14 teams in the American and National baseball leagues through which passengers reserve baseball tickets in cities along the United system. Coupons issued by the airline can be exchanged for tickets at "will call" windows at the ball parks.

► **Swissair** will begin Douglas DC-7 service on two of its South American routes beginning July 4. The new service, once weekly from Zurich to Buenos Aires and once weekly from Zurich to Sao Paulo, will replace Swissair's DC-6B aircraft. The Buenos Aires flight leaves every Sunday; the Sao Paulo flight every Thursday.

► **Trans-Canada Air Lines** will begin nonstop Lockheed Super Constellation service between Toronto and Vancouver on June 1. TCA officials say this new service, combined with additional services east of Montreal to the Atlantic Coast provinces and an increase from nine to 12 transatlantic flights, will give TCA 20% more passenger carrying capacity on its new summer schedules.

AIRLINE OBSERVER

► Airline pilots are complaining that lack of remote radio stations at the Atlanta air route traffic control center are causing en route delays at fix points. Pilots protest that high-performance aircraft are often required to circle fixes while waiting for clearances to continue because of lack of communications. Although the center will handle as many as 6,300 fix postings on a busy day—as compared with 7,000 at the Washington center—all radio contacts are relayed through company radio. The center is without radar equipment and there is an urgent need for at least two more VHF frequencies, pilots say.

► **Landing fees at British airports will be increased by 37% effective June 1. Hangar rental and parking charges also are likely to be increased at a later time. Action follows criticism in Parliament of financial losses at many British airports.**

► Soviet government has agreed to accept a permanent representative of Air France in Moscow. Only other non-Iron Curtain airlines with representatives in Moscow are Scandinavian Airlines System and Finair, both of which fly directly to Moscow from Scandinavian points. Named to the new post by Air France is Russian-speaking M. Elie Tolstoy, a distant relative of the famous Russian novelist. Earlier talks between Aeroflot, Soviet-owned airline, and Air France for a Peking-Moscow-Prague-Paris service were suspended last fall because of the Hungarian crisis.

► **Navy last year leased 23 aircraft to commercial airlines to bring the Navy's total fleet on lease to 27 for an annual return of $1.4 million.**

► Sud Aviation will spend up to $1.5 million on its U. S. promotion of the Caravelle jet transport. This amount has been budgeted by Georges Hereil, Sud president, in his gamble to sell the French transport to carriers in the U. S.

► **Capital Airlines and the International Assn. of Machinists reached an agreement after a last-ditch 16-hour, all-night meeting to avert a threatened strike. Wage boosts range from 18 cents per hour for cleaners to 21 cents for mechanics and 24 cents for inspectors and lead mechanics. The union asked 25 cents for mechanics, Capital offered 18 cents before the compromise, 21 cents was reached. The airline also agreed to settle immediately a total of 279 grievances filed against it. Pay raises are retroactive to Oct. 1. This will cost the airline approximately $450,000.**

► U. S. District Court in Cheyenne, Wyoming, has ruled that airlines cannot be held responsible for failing to complete air freight shipments according to published timetables. The decision was the result of a civil suit brought by a florist against Frontier Airlines for failure to deliver a flower shipment from Salt Lake City to Laramie, Wyoming. Flowers were removed because of weight limitations. Federal judge ruled that a "carrier assumes no obligation to commence or complete transportation within a certain time."

► **International Civil Aviation Organization has allocated $1,368,300 for its 1957 technical assistance program as compared with $1.2 million in 1956 and $290,175 in 1951 when the program began. Bulk of 1957 funds have been earmarked for airport construction and installation of technical facilities in Near and Far Eastern countries.**

► Northwest Airlines has extended its family fare rates to include Saturdays to compete with the Capital Airlines rate which became effective when the allowable suspension period of 180-days was allowed to elapse prior to a Civil Aeronautics Board investigation (AW April 22, p. 47). CAB found that the adjusted rate may be "unjust and unreasonable" but added that "it would be inequitable to suspend Northwest's proposal as Capital Airlines already permits family fare travel on Saturdays from and to many points served by Northwest."

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AMERICAN AIRLINES

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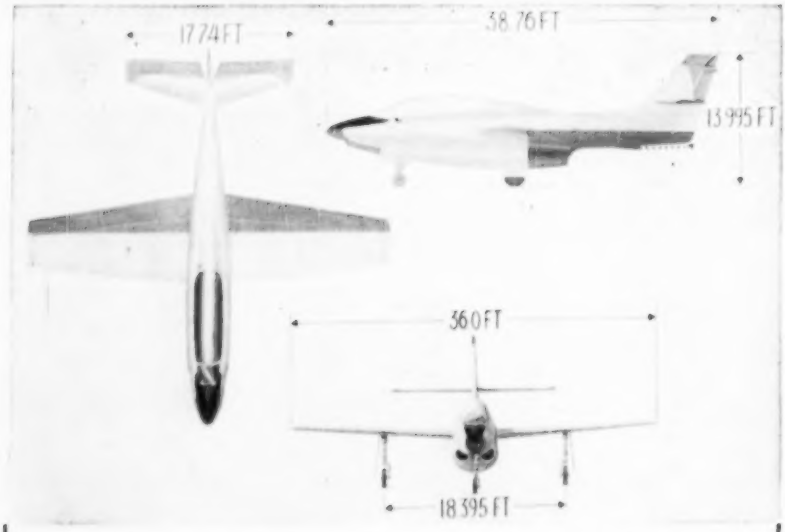
Airline Income and Expenses—February 1957

(In Dollars)

	Passenger Revenue	Mail Revenue (U. S.)	Express Revenue	Freight Revenue	Total Operating Revenue	Total Operating Expenses	Net Operating Income
DOMESTIC TRUNK							
*American	$18,279,857	$532,223	$336,246	$1,181,629	$20,694,935	$21,579,316	$884,381
*Braniff	5,622,416	113,840	87,722	78,253	5,984,621	6,472,969	488,348
†Capital	3,462,721	95,085	40,381	80,820	3,739,063	3,860,187	161,807
Continental	1,250,633	33,799	10,213	30,250	1,451,464	1,386,415	65,049
Delta	5,831,801	130,968	80,632	138,347	5,835,716	5,748,092	35,252
Eastern	19,740,942	344,355	826,311P	P	21,062,171	19,905,915	1,116,443
††National	5,563,212	98,708	26,800	126,789	6,083,437	4,931,514	1,140,075
Northeast	638,009	9,714	6,916	15,085	852,342	1,122,498	†269,318
Northwest	2,743,926	122,967	272,930P	P	3,170,834	3,771,913	†601,079
†Trans-World	10,638,154	336,345	781,977P	P	12,183,896	14,203,598	2,092,261
United	15,348,127	691,498	317,403	719,487	17,248,449	19,106,192	†1,857,743
Western	2,705,891	81,915	38,118	51,443	2,926,732	2,670,102	219,486
INTERNATIONAL							
American	485,531	4,081	157	60,400	576,877	513,112	63,765
Braniff	432,895	92,302	.....	27,733	591,392	516,502	69,527
Caribbean-Atlantic	160,221	1,891	.....	.....	174,886	146,035	28,851
Delta	446,593	4,653	.....	14,712	486,345	380,173	109,691
Eastern	1,155,756	29,318	17,707P	P	1,202,282	931,252	268,757
††National	.....	.....	.....	.....	.....	.....	.....
Northwest	995,824	449,404	260,126P	P	1,778,735	1,881,954	†103,218
Pan American							
Alaska	191,000	15,000	37,000P	P	237,000	557,000	†320,000
Atlantic	5,368,000	571,000	889,000P	P	7,290,000	8,506,000	†1,216,000
Latin America	5,267,000	168,000	1,179,000P	P	6,944,000	7,590,000	†626,000
Pacific	3,898,000	417,000	643,000P	P	5,529,000	5,697,000	†168,000
Panagra	1,272,598	36,280	.....	128,716	1,679,554	1,570,279	116,103
Trans-World	2,097,399	372,275	361,808P	P	3,115,900	4,363,838	†1,287,536
United	819,070	25,448	.....	14,789	870,912	891,576	†20,664
LOCAL SERVICE							
Allegheny	295,533	6,409	10,128	5,738	459,415	643,041	†183,626
Bonanza	147,358	2,798	1,270	3,002	254,000	253,196	655
Central	82,801	3,017	1,154	2,939	266,396	307,456	†41,060
Frontier	232,695	227,067	2,279	16,774	495,977	512,475	†17,691
†Lake Central	101,202	2,720	5,666P	P	220,389	252,972	36,000
*Mohawk	.....	.....	.....	.....	.....	.....	.....
North Central	464,952	16,044	11,618	.....	622,591	732,368	†109,777
Ozark	216,602	180,197	5,584	5,042	416,310	520,068	†103,758
Piedmont	284,100	6,299	3,948	3,957	508,727	619,652	†110,925
†Southern	151,783	7,998	3,301	.....	307,018	348,258	41,240
*Southwest	.....	.....	.....	.....	.....	.....	.....
Trans Texas	240,938	8,121	3,604	8,261	493,481	535,657	†42,176
West Coast	165,509	3,446	1,124	2,193	325,917	333,565	†7,648
HAWAIIAN							
†Hawaiian	296,946	2,863	.....	50,833	381,441	413,633	32,192
Trans-Pacific	125,258	.....	5,742P	P	138,454	172,369	†30,337
CARGO LINES							
*Aerovias Sud-Americana	.....	.....	.....	.....	.....	.....	.....
Flying Tiger	36,737	8,806	721,190P	P	1,094,707	934,945	258,414
Riddle	.....	9,743	542,916P	P	595,119	735,385	†153,862
*Seaboard-Western	.....	.....	.....	.....	.....	.....	.....
*Slick	.....	.....	.....	.....	.....	.....	.....
HELICOPTER							
†Chicago Helicopter	5,708	67,032	.....	.....	77,540	89,055	*11,515
Los Angeles Airways	12,233	7,629	6,285	.....	101,239	93,631	6,890
New York Airways	25,784	2,991	1,438	2,524	132,634	193,156	†60,523
ALASKAN							
Alaska Airlines	89,842	38,337	47,229P	P	375,850	431,851	†55,918
Alaska Coastal	35,371	8,495	.....	4,526	86,113	95,695	†9,582
*Cordova	.....	.....	.....	.....	.....	.....	.....
*Ellis	.....	.....	.....	.....	.....	.....	.....
Pacific-Northern	263,524	38,686	48,547P	P	615,318	706,729	†91,211

Compiled by AVIATION WEEK from airline reports to the Civil Aeronautics Board.
P—Total property figure; express; freight; excess baggage
*Not available
**Net operating loss after taxes
†Net operating loss before taxes
††National—all services figures



FULL-SCALE MOCKUP of T2J-1 (above) shows big tail providing good low-speed stability, also large amount of rudder below stabilizer to provide effective control in spins. Cutaway (right) details underbelly placement of equipment and engine for ease of maintenance. Instructor sits higher than student, is seated ahead of wing leading edge to give him wide visibility range.

North American (Model 249) T2J-1 Specifications

(1 Westinghouse J34-WE-46 @ 3,400 lb. thrust)

Maximum gross takeoff weight	**9,507 lb.**
Service ceiling	**41,000 ft.**
Maximum speed	**429 kt.**
Wing	
Total area	**255 sq. ft.**
Flap area (total)	**50 sq. ft.**
Aileron area (total)	**19.0 sq. ft.**
Airfoil (root and tip)	**NACA 64A212 mod.**
Horizontal tail	
Total area	**68 sq. ft.**
Elevator area (incl. tab)	**17.66 sq. ft.**
Vertical tail	
Total area	**38 sq. ft.**
Rudder area (incl. tab)	**10.71 sq. ft.**

T2J Designed

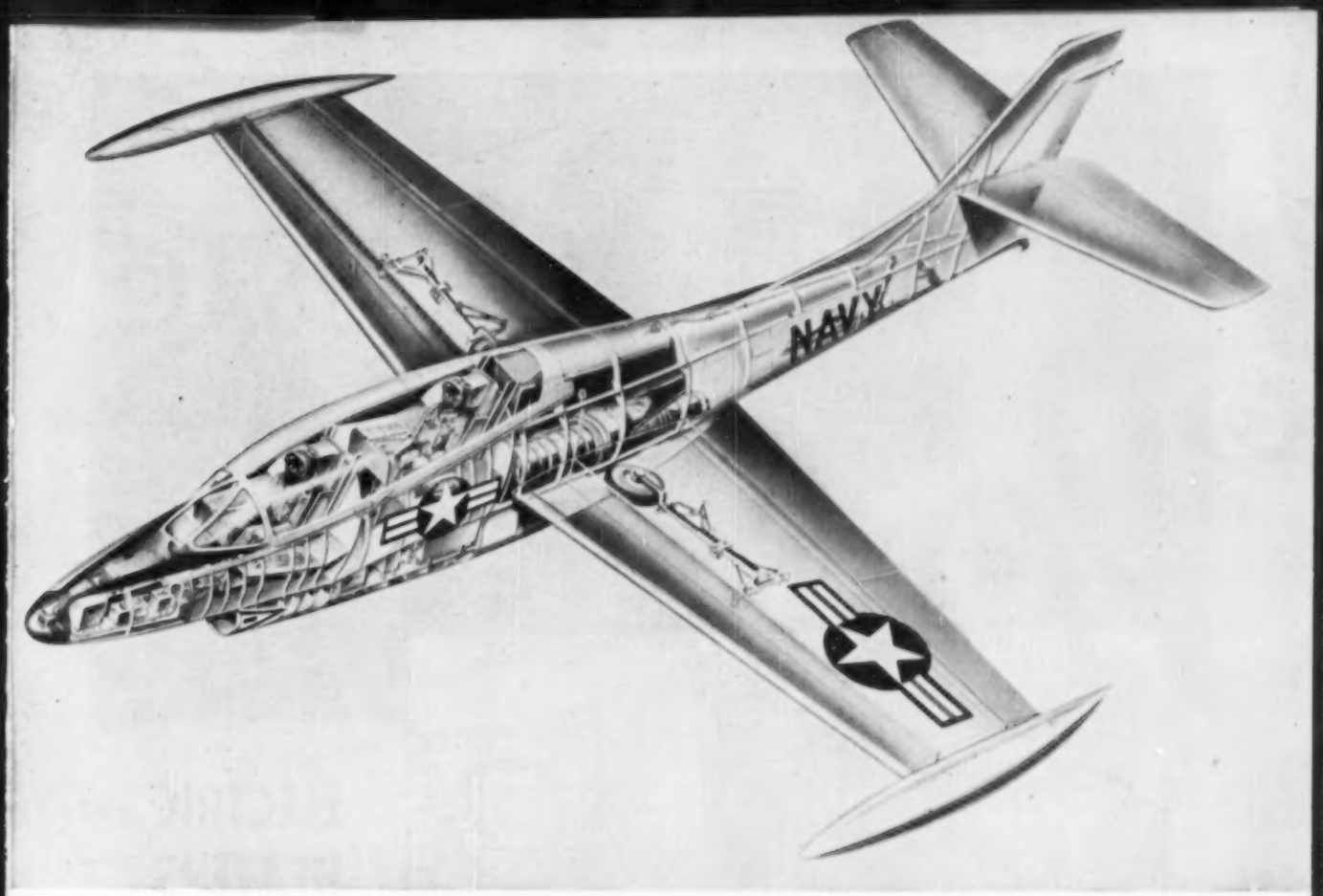
by Erwin J. Bulban

Columbus, Ohio—North American Aviation's new T2J-1 two-place jet trainer is designed as a complete pilot training system, capable of taking students from primary through advanced phases including Navy carrier indoctrination.

Versatility of the airplane—first to be wholly conceived, engineered and produced at NAA's Columbus Division—is such that it could shave at least a month from current student training programs, which involve switching to several types in the course of normal curricula. Present loss of time in becoming familiar with each airplane will be eliminated, according to company personnel familiar with the T2J-1 state. They claim it is the first U.S. jet trainer with such capability.

"Substantial" Contract

It is on this basis, and with a Navy contract for a "substantial" number of T2Js on its books, that North American is sending a sales team abroad this month to negotiate additional contracts



as Primary-Through-Advanced Trainer

with friendly foreign powers. Initially, the three-man team, comprising Frank G. Compton, director, development and planning; F. W. Howells, manager, technical sales and Lynn Helms, technical sales representative, trainer aircraft, will show a model of the T2J at the Paris Air Show late this month.

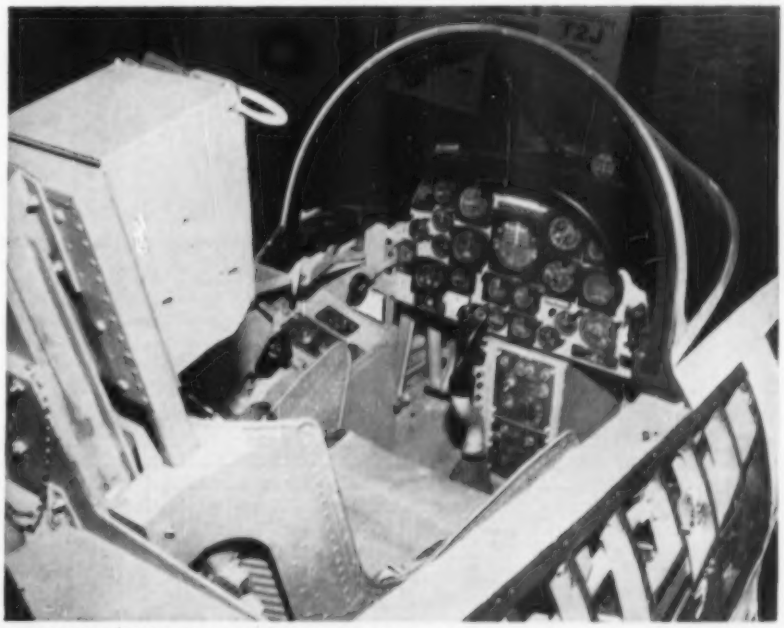
No firm itinerary is planned by the sales team, although it plans to have discussions with West German air force leaders and follow any leads established during the air show.

Flight This Year

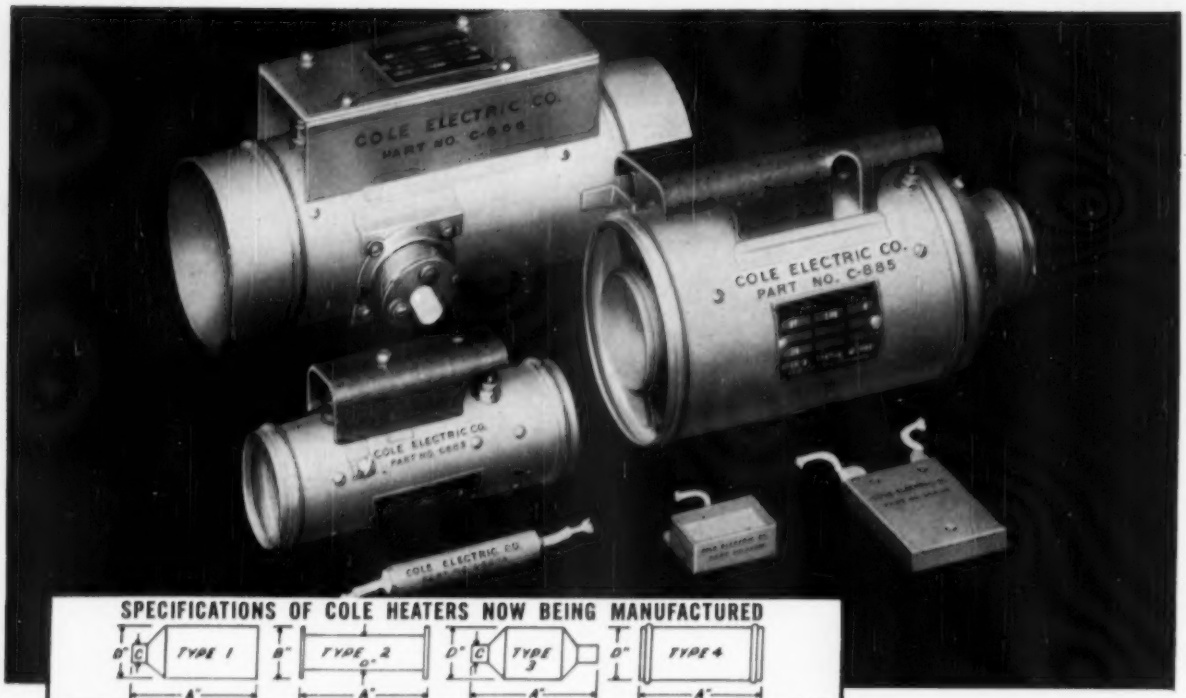
A trip to England is also planned, where the team will talk to Bristol about application of the Orpheus turbojet to the T2J. NAA already has submitted data to Royal Canadian Air Force and plans to make proposals on an Orpheus-powered Model 249 (company designation for the TJ2) to RCAF, which is studying several jet trainer projects.

NAA already has made overtures to USAF. The full-scale T2J-1 mockup at Columbus has been studied by the Air Force.

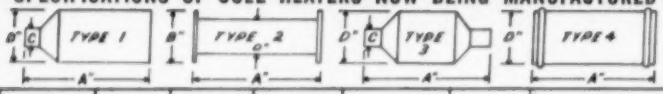
First T2J-1 is scheduled to fly by the



STUDENT'S COCKPIT (mockup) can be fitted with ordnance control pedestal under instrument panel.



SPECIFICATIONS OF COLE HEATERS NOW BEING MANUFACTURED



CAT. NO.	CAPACITY K.W.	VOLTAGE	RATED AIRFLOW LBS/MIN.	TEMP. RISE AT RATED AIRFLOW °F.	THERMAL LIMITER	TYPE	DIMENSIONS A	B	C	D
C-970	.6	27	1.7	82	Thermo./Link	4	6			2
C-672	.75/.37	27	5	34/17	Thermostat	4	8½			3
C-1122	1	115	15	15	Fusible Link	Blower	1½			3¾
C-665	1./.67/.33	27	5	46/31/15	Thermostat	3	8⅝			3½
C-553	2	27	6	77	Thermostat	3	9		1	2
B-1246	2	27	10	47	Thermo./Link	4	6⅞			1½
C-667	2/1.3/.7	115	3	155/115/54	Fusible Link	2	6½			3
C-883	2	27	6	76	Thermo./Link	4	6			2
C-990	2	27	6	76	Thermo./Link	4	6			2
C-995	2	27	7.5	62	Fusible Link	2	2½	8		6 9/16
C-1258	2/4	27	2	230/460	Thermostat	2	10 3/16	6		5
C-660	2	115	11	42	Thermostat	4	7			3
C-726	2.1/1.05/.55	27	4	123/61/30	Thermostat	4	9½			3
C-1079	3	115/200	3	230	Thermostat	2	13	3⅛		3½
D-611	3	115/200	22	30	Thermostat	Misc.	25			7
C-561	3	115	3	235	Fusible Link	4	13			3½
C-666	3/2/1	27	10	70/47/23	Thermostat	4	10¼			3½
C-1329	3.5	115/200	40	20	Thermostat	2 (Blower)	13⅝	6-1/16		5
C-885	4	27	14	66	Thermo./Link	1	8½		2	4
C-980	4	27	6	155	Thermo./Link	4	9 15/16			2
D-312	4	27	10	94	Thermostat	1	8½		2	4
C-932	5/2.5	27	15	70/35	Fusible Link	4	9½			4
C-1082	5	115/200	15	70	Thermostat	4	15⅜			4
D-553	5/10/15	115/200	130	8/16/24	Thermostat	2 (Misc.)	20	6¼		6
C-562	5	115	15	70	Fusible Link	4	15⅜			4
C-602	6	27	10	140	Thermo./Link	4	11¼			4
B-1413	6	27	13	108	Fusible Link	2	5⅛			3
C-747	6/3	27	15	94/47	Fusible Link	2	6⅝			4
C-662	7	27	15	108	Fusible Link	4	9½			3
C-671	7/3.5	27	50	32/16	Fusible Link	4	9½			3½
C-787	7/3.5	27	8	205/102	Thermo./Link	4	9½			3½
C-1329	7.5	115/200	18	96	Thermostat	2 (Blower)	14½	8⅞		7¾
C-607	9	115	4	525	Fusible Link	4	15			4
C-648	9	115	8.33	255	Thermostat	4	15			4
							Length	Width		Height
A-7385	.05	27	Conduction	920°F	—	Flat	1½	1.7		⅝
A-6645	.058	27	Conduction	920°F (60W/IN²)	—	Tube	3			½
A-6649	12	27	Conduction	1000°F	—	Flat	2¾	2		⅜
D-608	1.15	115	Conduction	170	Thermostat	Water	13½			
C-1319	3	115/200	22	30	Thermostat	Misc.	27	11⅞		6
C-1278	10	115/200	30	70	Thermostat	Misc.	10	8		7⅝
C-1320	27	115/200	170	36	Thermostat	Misc.	27	11⅞		6
C-1271	30	115/200	150	46	Thermostat	Misc.	25	16		4

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end of this year. NAA-Columbus is only weeks away from complete engineering drawing release and some parts are already moving through the shops. Space for production of the jet trainer has been made adjacent to the FJ-4B Fury fighter line.

Airplanes will be production configuration from the start with no "X" model. Company has been negotiating with Navy to support initial batch of production models through accelerated test schedules.

Design Concept

Design concept of the T2J-1, according to North American-Columbus, involved engineering for safety with plus factors of reliability, versatility, maintainability, all adding up to economy.

In working toward this goal, T2J Project Engineer Walt Mazur laid out an airplane combining simple, conventional structures conventionally fabricated, using for the most part off-the-shelf equipment to ease logistics and cost problems and building in a high degree of maintenance by placing auxiliary equipment and a proven powerplant external of primary structure.

Basically, the T2J-1 is a tandem-seat, straightwing configuration with a single Westinghouse J34-WE-46 producing 3,400 lb. thrust and having a level flight speed of 429 kt.

Engine selection is one example of using proven equipment: J34 has achieved 1,000-hr.-plus before overhaul status and features an all-steel compressor with a record of being less than half as vulnerable to foreign object damage as other comparable engines. Westinghouse has kept limited pilot line production going on this engine; indications are that it will undergo some modernization for the T2J.

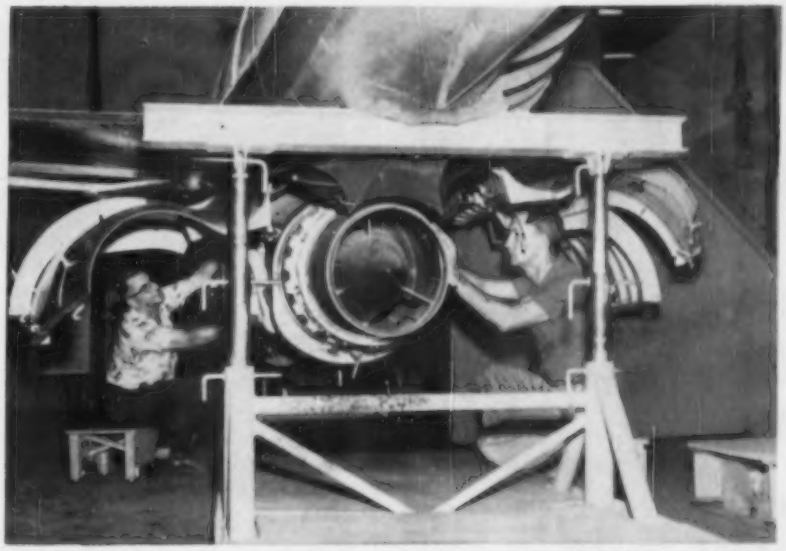
Structurally, as an example of hewing to the proven, NAA-Columbus uses what is essentially the 12% wing of North American's first jet fighter, the FJ-1 Fury. Dimensions and makeup are similar, airfoil is the same modified NACA 64A212.

The T2J utilizes the basic control system of the NAA T-28 Trojan piston-engine trainer, with a simple boost system added.

Stock Items Used

Logistically, the new trainer bypasses many new components in favor of items available in large quantity in Navy's inventory, in some cases imposing weight increases compared to new equipment. Landing wheels on the T2J, for example, are approximately 14 lb. heavier than new types, but Navy has large stocks of the ones NAA chose, AVIATION WEEK was told.

Cost figure indications are that the T2J is designed to operate at figures that compare favorably with the company's T-28 piston-powered trainer.



LARGE PANELS hinge open quickly to allow ground personnel complete access to J34 turbojet without straining. Engine removal replacement test by NAA was completed in 27 min.

NOSE BAGGAGE COMPARTMENT also serves for placement of equipment systems, such as gun fire control or ILS units. Items are tray mounted for quick removal-replacement.

Indications also are that this design philosophy and cost picture played an important role in the T2J-1 being awarded a production contract over approximately 18 other manufacturers last July.

Human engineering studies by North American engineers planning their new project around safety criteria covered qualitative as well as quantitative approaches. Quantitative data inferred that side-by-side seating would have a safety edge over the tandem arrangement. Studies in the field—including interrogation of instructors, 85%-95% of whom said they desired the tandem arrangement—resulted in choice of this layout.

Instructors were also queried about stall speeds. They generally agreed that about 85 kt. was the desired minimum, but NAA planned the T2J for approximately 65 kt., experience teaching that students add knots coming in, for life insurance.

Ejection seat design was planned around safe exit at ground level. NAA reworked the Martin-Baker seat, providing rocket power that boosts the pilot out to about 200 ft. Safe ground level ejections can be made at above

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SOUTHWEST AIRMOTIVE COMPANY
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Pratt & Whitney Aircraft
Division of United Aircraft Corporation
East Hartford, Connecticut

BATTERY swings out for ground checking. There is sufficient room in this compartment for mechanic to check status of jet engine compressor blades.

COMPARTMENTED equipment bay has access panel opened by pushing two latch-type fasteners. When closed, panel seals off compartments from each other.

70 kt., and a chute larger than that used on the Martin-Baker seat provides more positive separation, AVIATION WEEK was told. In addition, seat rails and head-rest were narrowed to approximately 9 in. width to give the instructor a clearer view forward. Instructor's forward view is further enhanced by jogging floor at the rear cockpit upward so he sits 10 in. higher than the student.

A large tail was used to provide good stability and positive control at low speeds. NAA studies indicated that approximately 80% of USAF and Navy aircraft accidents occurred during landings and takeoffs and of these, 94% could be attributed to loss of control.

Horizontal tail was mounted high to minimize buffeting. Good spin recovery is planned by placing 45% of the rudder below the horizontal tail to prevent it from being effectively blanketed.

Simple hydraulic boost system for controls, utilizing 3,000 psi. is used on ailerons and elevators, with ratios of 12:1 and 3.3:1 respectively. Rudder is full manual operation. Another 3,000 psi. system takes care of the 8 sq. ft. fuselage dive brakes, tricycle landing gear and carrier arresting gear.

Control boost system is laid out so that some hydraulic energy is fed back via pistons to give pilot feel. Should hydraulic pressures fall off, sources applied to the boost cylinder are mechanically transmitted to move the controls. NAA-Columbus plans to provide boost switch-off from the cockpit so that students can be given training in handling the airplane without its aid.

Wide range of mission capability planned for the T2J includes initial checkout, instrument, navigation, formation, acrobatics and pilot proficiency training. As one NAA spokesman put it, "This airplane is designed to take everybody, from cadets to commanders."

For combat crew training, the airplane will be capable of providing gunnery, rocketry, bombing and tow-target missions. Designed to operate without restrictions in any configuration with or without tiptanks, the T2J will also be capable of simulating special weapons delivery techniques. Optional ordnance packages designed for it include gun packs, tow target pack, 100-lb. practice bombs, M-5 practice bomb clusters, Type T-1 practice bomb containers, 2.25-in. rocket launcher assemblies and 2.75-in. Mighty Mouse Aero 6A rocket packs.

As part of the T2J pilot training system, North American developed a closed-circuit transistorized TV gunnery instruction monitor (Nagim), which provides the instructor with a constant picture of the view the student has through his front windscreen, including sight reticule. This non-collimated picture allows the instructor to check the student's progress constantly during weapons firing runs and give help if needed.

Considerable time saving as well as more efficient instruction is expected using Nagim over conventional gun camera training where the student must wait processing and projection of his film before learning results and assessing his technique

Maintainability received special attention in the T2J project. Major feature here was providing a fuselage structure from which equipment and powerplant are suspended independent of primary members.

Horizontal stabilizers, elevators, aileron and trim tabs are interchangeable from side to side, main landing parts are interchangeable at assembly. Any control surface or tab can be changed without disturbing the control rigging.

Large bays, on left and right sides, house equipment in compartmented areas that are sealed when panels are fastened. One large panel, held by

COSTS OUGHT TO COME DOWN

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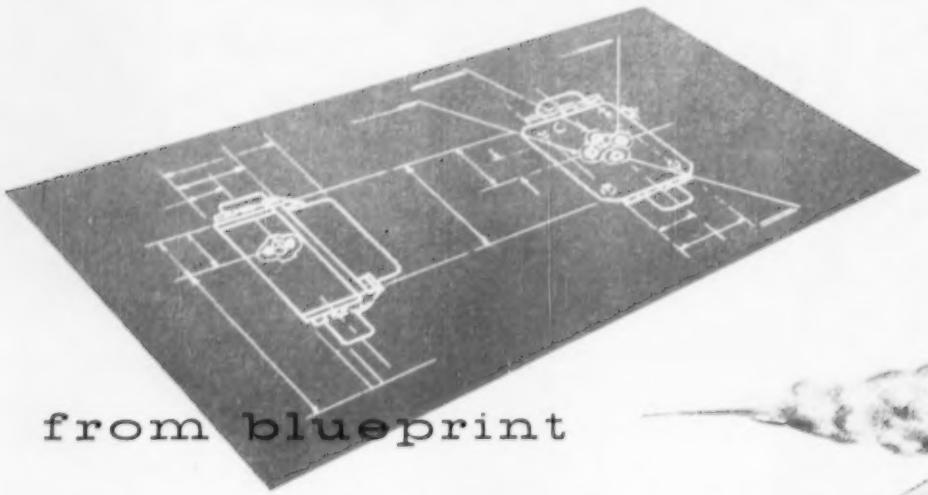
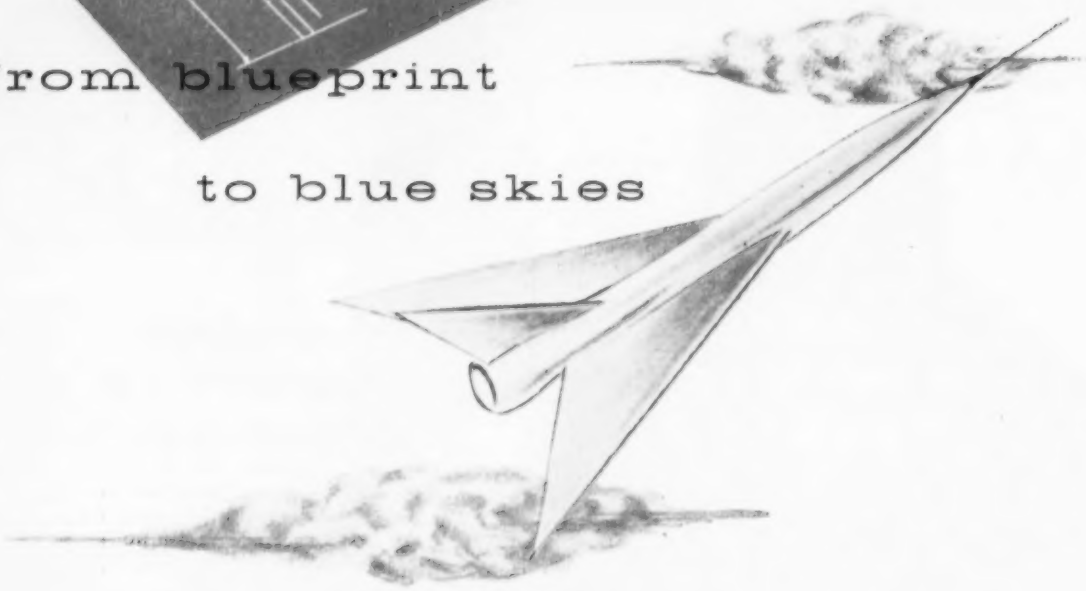


from blueprint

to blue skies



From design concept to volume production, Moog's contribution to high performance electro-hydraulics has been unique. Originators of force-balanced nozzle-flapper* and of dry-motor servo valves*, Moog alone has been able to translate these concepts into full volume manufacture. The 40,000 units in the field verify a production record unmatched in the industry. Consult Moog if this kind of design-to-production performance is desired.

*Patented
Other Patents Pending

ELECTRO-HYDRAULIC SERVO MECHANISMS

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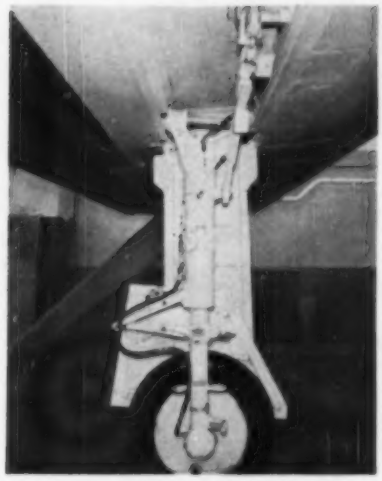

MAIN gear mockup has 18.4 ft. tread.

two quick-opening press-type latches, completely exposes all equipment in each bay. Engine bay is similarly exposed by a single large panel on each side.

Layout of systems equipment in left and right-hand bays is such that wiring from consoles in cockpits above leads directly downward to the appropriate bay on the same side as the console, making for minimum length leads and facilitating circuit tracing and trouble shooting by maintenance personnel. Only wiring that runs laterally, according to NAA, is that to the lights in wingtip tanks. Basic layout puts a.c. equipment on the right side and d.c. on the left.

Additional equipment, such as fire control or instrument landing systems, can be tray-mounted in the hinged nose for quick removal and replacement.

Fuel and oil fillers are on the left-hand side between equipment and engine bays. Fuel system will take either regular or pressure loading.

Engine suspension beneath primary structure also makes for speedy removal. In test on the mock-up, the J34 was removed, using a modified BuAer bomb dolly. Engine takeoff time was seven minutes, replacement 20 minutes.

Main fuel cell, containing 381 gal., is directly over the engine and if boost pumps should give out, gravity flow and engine suction would be sufficient to provide military power up to 12,000 ft., according to the company.

Tiptanks of 100-gal. capacity each bring total fuel to 581 gal., allowing a range of 840 nautical miles. Fourteen touch-and-go training cycles can be made without external fuel. This includes five-minute warmup, climb at military power for one-half minute, five minute cruise at sea level and 9% reserve and taxi allowance after the final landing.

The T2J is designed to takeoff and clear a 50 ft. obstacle in 2,900 ft. Landing requirement over 50 ft. is estimated at 1,690 ft.

Fuselage structure is semi-monocoque comprising four main longerons from the nose equipment/baggage compartment to the vertical stabilizer. Flooring starts at the nose compartment, runs through the cockpit area below the fuel cell and ends as the ceiling of the engine bay. Floor skin ranges from .040 to .025 aluminum alloy except in the engine bay area, where it is stainless steel. Lower fuselage skin also is stainless steel in the engine blast area. Fuselage will be produced in three main sections: cockpit; intermediate section, containing fuel bay, powerplant area and wing carry-through structure; and the aft section. All connections are production splices.

Two large aluminum forged beams go through the intermediate fuselage. Wings are attached to these by four main bolts and a drag bolt on each side. An I-beam in the belly, forward of the engine section, carries catapult and tow-target hooks. Loads from these feed into the I-beam, into the peripheries of the two engine air intake ducts, and from there to the floor.

Guided missiles of the future are *on our scopes today*—thanks to the agile brain of an amazing new ECM Simulator developed for the Air Force by Hallicrafters RDA.*

Designed for advanced study of jamming, deception and countermeasures techniques, the device furnishes to the PPI scope exact simulations of moving targets, and jamming, *in infinite variation.*

Programming may be generated according to predetermined plan, or targets may be controlled manually. *Speeds as fantastic as 270,000 m.p.h.*, as well as radical directional changes, now can be simulated for planning tomorrow's countermeasures.

ECM Simulator is another example of electronic design leadership that has made Hallicrafters a prime mover of key military projects for over 22 years.

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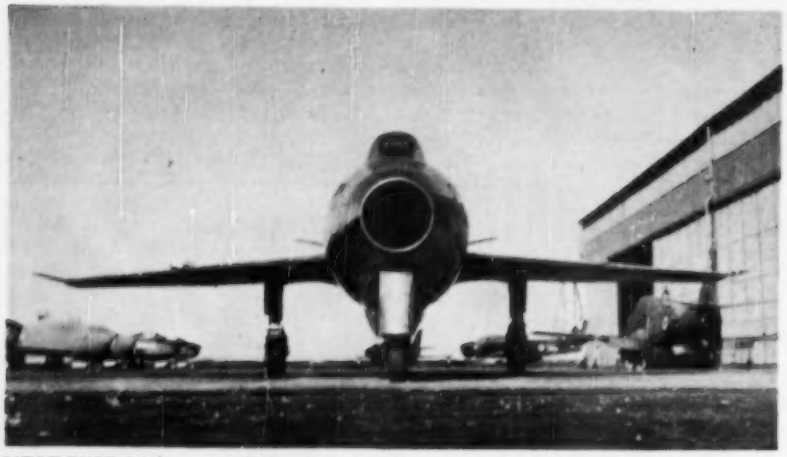
*Rapid Development Assistance

Sagittario Bids for Light Fighter Role



PITOT-TYPE intake serves Rolls-Royce Derwent engine in Sagittario II fighter.

ENGINE inclines in nose and exhausts under belly. Layout eases access.

STAINLESS STEEL extension aft of tail pipe insulates fuselage from jet blast.

Rome—Aerfer Sagittario II, originally classed as an experimental aircraft, has become another entry in the European list of lightweight fighter-assault planes designed for economy and ease of production by nations with limited resources.

The transonic Italian design with a 45 deg. leading edge sweepback is stressed for speeds up to Mach 1.2. Installation of the Rolls-Royce Derwent 9 engine is in the nose and low, providing ease of access and maintenance. This also makes for roomy pilot accommodations and ample space for fuel and armament.

Later Engine

Use of the Derwent 10 engine of 5,000 lb. thrust, providing 1,400 lb. more than the present engine, is possible if the later model engine goes into production.

Sagittario II is convertible to either of two missions:

- **Day interceptor,** with high rate of climb and smaller fuel and armament load.
- **Tactical support,** with armament augmented by underwing stores and additional fuel needed for lower operating altitude and combat flexibility.

Airplane is stressed to withstand an ultimate load factor of 12. Aluminum alloy of high strength is used (Superavional and Ergal).

Cockpit, opening on rear hinges, is pressurized and equiped with a Martin-Baker ejection seat.

Horizontal tail surface is composed of a single piece stabilizer which carries the fuselage and an elevator made up of two parts. Stabilizer is hydraulically actuated and may be connected with the stick in order to obtain synchronized motion with the elevator.

Dowty tricycle landing gear with liquid spring type shock absorbers is used.

Armament consists of two Hispano-Suiza guns (30 mm.), installed forward of the center wing.

Wing Structure

The cantilever wing carries through the fuselage and is characterized by a 45 deg. sweep-back at leading edge, a low aspect ratio and laminar airfoil.

Slotted type ailerons are so dimensioned to insure a good lateral stability even at high speeds. They are statically and dynamically balanced and are controlled by means of a Fairey hydraulic booster. Immediately forward of the ailerons, and in line with their center line, are the spoilers. They are synchronized with the ailerons.

Flaps are of the slotted type and ex-

DESIGN CONCEPT of Italian fighter is simplicity. Engineering is for production ease for nations with limited resources.

tend from the wing root to the ailerons and are hydraulically operated.

Installation of the engine in the nose makes for a structural design similar to that of piston engine powered aircraft. Fuselage is built in one piece, including the fin. A bulkhead separates the engine zone from the cockpit.

Behind the cockpit are first the guns and ammunition box compartment and next the main fuel tanks integral with the fuselage structure and enclosed by three-seal bulkheads.

Behind the tanks is radio electrical equipment. Toward the rear of the fuselage are speed brakes, consisting of four doors which open fanwise. The rear of the fuselage has an opening on the sides through which the variable incidence stabilizer is fitted.

At the fin post the fuselage ends with a bulkhead, to which the fuselage end is fitted.

Below and behind the wing box, the fuselage has a stainless steel fairing to provide insulation from the exhaust.

To improve the thermal insulation between the fairing and the fuselage structure, a hollow space has been left, ventilated by means of air flow obtained by a raw air scoop.

The variable incidence stabilizer is actuated, through a hydraulic servo-control unit, by means of a lever at the left of the pilot's seat. This lever is connected by means of a rigid coupling, which can be disconnected, to the elevator controls.

Thus a flying tail is created in which the stabilizer may be trimmed by releasing it from the elevator control.

In case of failure of the hydraulic system, the stabilizer must be disconnected in order to leave the pilot free to operate the elevator manually.

Landing Gear

The landing gear is of the tricycle, retractable type and is hydraulically operated. Both the nose gear and the two main gears have liquid spring type struts, with trailing link.

The two main wheels have pedal controlled hydraulic brakes.

Retraction of the nose gear is forward with the gear housed in a well in the fuselage nose.

The main landing gear is situated behind the wing box and is housed in the fuselage. In the extended position, the main landing gear doors remain closed, thus improving the aerodynamic performance of the aircraft in the take-off operation.

Engine is tube mounted on the fuselage forward bulkhead. The engine suspension includes two main pins situated close to the engine's center of gravity and two rear fasteners which allow some axial displacement.

The engine is inclined upward; the rear end is fitted into an elbow which houses the tail pipe at the opposite side. The elbow is supported by a couple of links which allow its axial displacement and angular trim variation. The tailpipe is supported by the elbow at the front and by the external fairing at the rear. This second coupling is of the link type and allows axial and lateral displacement.

Aft of the exhaust pipe, the fuselage structure is insulated by the double wall air circulation and the stainless steel extension.

The engine is not connected directly to the fuselage nose shell in which it is installed.

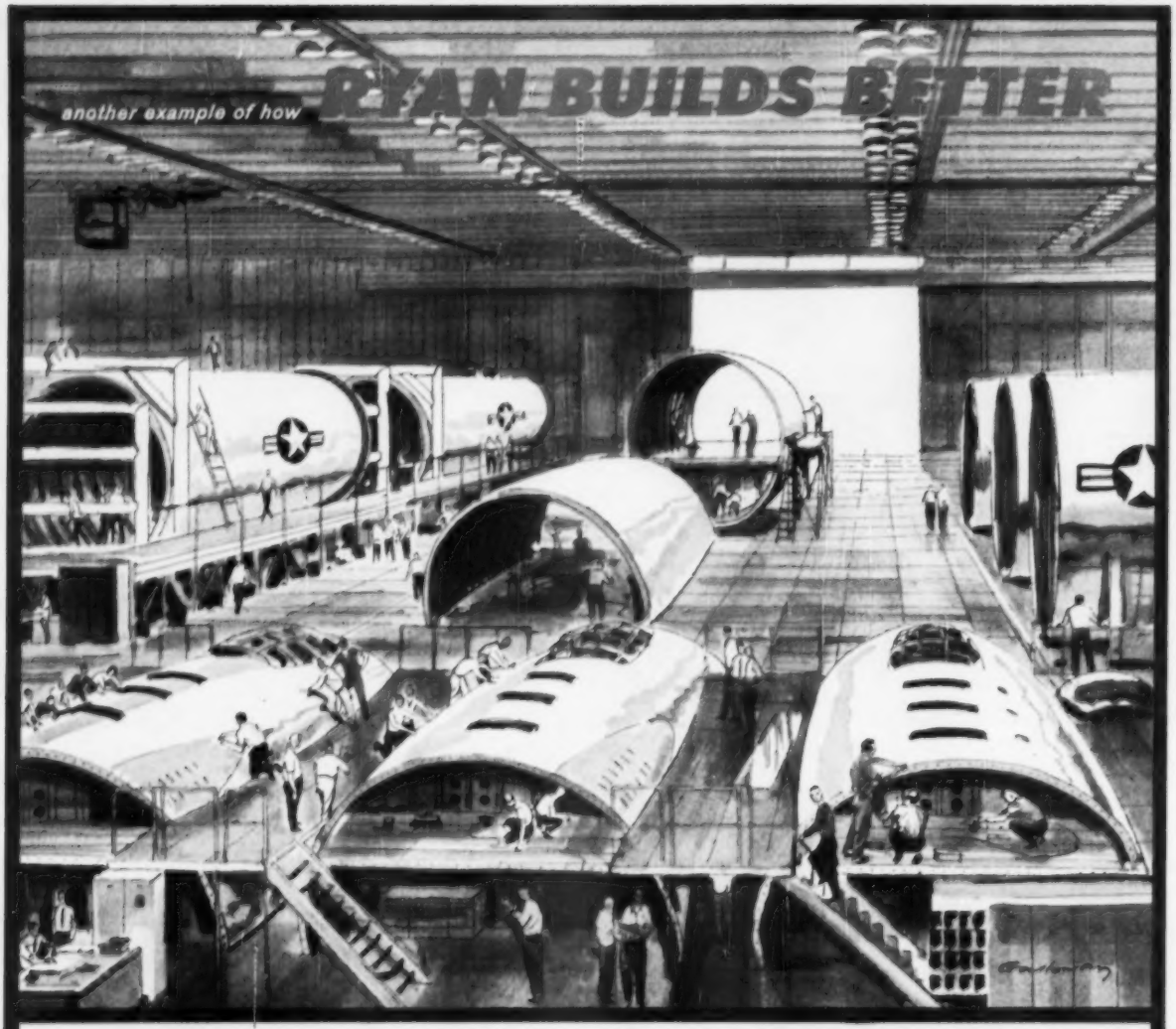
Nose Half Shells

The nose consists of two half shells which are joined according to the horizontal parting line at the front and with a slight inclination at the rear.

The upper half shell is hinged to the nose bulkhead of the fuselage and connected by pins with the lower half shell at the front ring; another set of linkings completes the connection of the two parts. The lower half shell is fastened to the nose bulkhead by means of four detachable fittings.

To allow frequent inspections of the engine, the two parts of the nose gear are disconnected and the upper half shell is lifted like a normal automobile hood. In case of inspection and work requiring greater freedom of movement, the nose cowling may be quickly disassembled, leaving the engine completely exposed.

With the nose cover, the nose wheel



RYAN BUILDS GIANT SECTIONS FOR JET TANKER-TRANSPORTS

The largest aircraft structure ever subcontracted for quantity production is being volume-produced by Ryan. Giant mid and aft fuselage sections for the Air Force KC-135—the nation's first jet tanker-transport—are steadily flowing from Ryan to Boeing's Seattle-Renton plants. Comparable sections are also being built by Ryan for the famous Boeing 707, America's first commercial jet airliner.

Ryan's ability to meet the myriad of new and exacting requirements of this huge project and produce and deliver on schedule, is the result of team "know-how" and drive based on many years' experience. This includes 7 years of volume production of similar fuselage sections for the predecessor to the KC-135, Boeing's propeller-driven KC-97 Stratofreighter. To meet this new challenge, Ryan specialists developed a whole repertoire of new techniques, including the most extensive and advanced use of resistance welding ever applied to basic airframe construction.

Ryan's unique capabilities—precision planning, close coordination with customers and quality production—are important factors contributing toward the ideal of maximum utilization of the nation's most efficient industrial capacity for defense production.

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Aircraft • Power Plants • Avionics

Ryan Aeronautical Company, San Diego, Calif.

Ryan

which is fitted to it also is removed. In this case, the third point of support of the aircraft is provided by special jigs for this purpose.

The tank system is pressurized at 210 gr/cm².

Fuel is stored in four fuselage tanks giving a total fuel capacity of 312 gal., sufficient for accomplishing the ground attack mission. For the interception mission the utilization of only two tanks is foreseen, with a fuel availability of 170 gal.

Armament

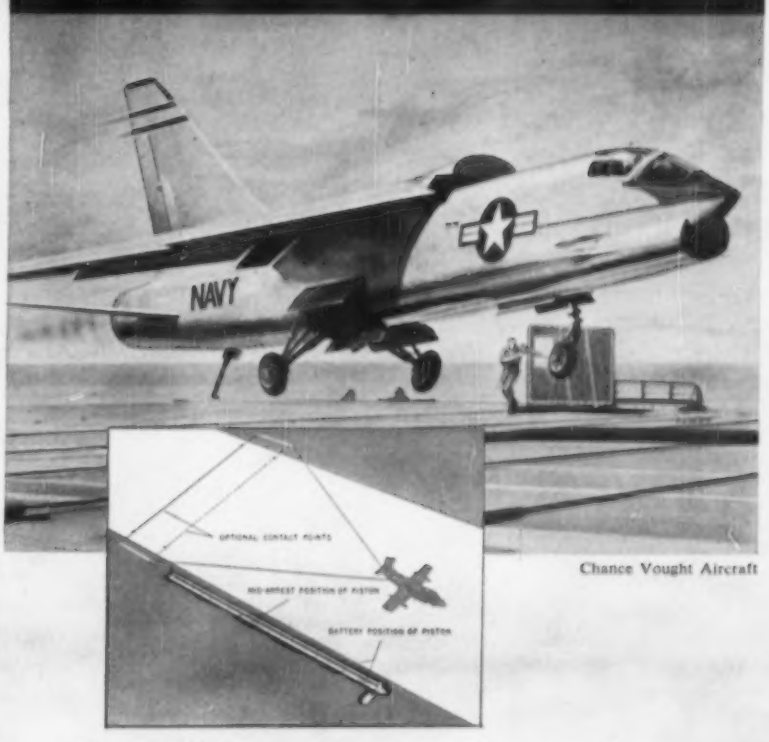
The two 30 mm. Hispano-Suiza guns are mounted on the fuselage about at the center of gravity to avoid stability problems during firing.

The guns are fastened, by means of a universal joint, to the main fuselage bulkhead. Recoil is directly discharged on the wing box by means of two stiff

Sagittario Performance

Length	30.4 ft.
Span	24 ft.
Wing Area	155 sq. ft.
Empty weight	4,950 lb.
Total fuel capacity	312 gal.
Maximum ammunition capacity (fuselage guns)	2 x 150 rounds
Maximum wing armament load	1,430 lb.
Total Weight:	
Normal, as interceptor (fuel 1,144 lb.—200 rounds)	7,260 lb.
Maximum, as interceptor (fuel 2,068 lb.—300 rounds)	8,360 lb.
Maximum, as tactical attack plane	9,790 lb.
Performance (normal load):	
Takeoff space on 50 ft. obstacle	2,720 ft.
Climb to 29,000 ft	5 min.
Climb to 39,000 ft	8 min. 30 sec.
Service ceiling (V_a = 1 m/sec)	45,000 ft.
Sea level climbing speed	8,000 fpm.
Maximum speed	650 mph.
Range (normal fuel load):	
Range, including climb to 29,000 ft.	475 mi.
Maximum endurance at 29,000 ft.	1 hr. 10 min.
Residual range after climb to 29,000 ft and 10 min. full throttle flight (combat)	250 mi.
Range (maximum load):	
Range including climb to 29,000 ft.	985 mi.
Maximum endurance at 29,000 ft.	2 hr. 20 min.
Residual range after climb to 29,000 ft. and 10 min. full throttle flight (combat)	715 mi.
Attack Mission:	
Takeoff over 50 ft. obstacle	4,680 ft.
Sea level maximum speed	600 mph.

ALL AMERICAN INGENUITY



Chance Vought Aircraft

A tight squeeze for safety

It is impossible to squeeze water but All American has developed a water "squeezing" principle to increase the safety of commercial jet transportation.

Absorbing energy by drawing a piston through a water-filled pipe has resulted in arresting gear now in service with the Armed Forces.

Now All American engineers have carried the water "squeezing" principle one step further and have developed an emergency overrun barrier for commercial airports. Stopping jet transports in a few hundred feet in case of brake or reverse thrust failure, this new concept prevents loss of million-dollar aircraft and possible injury to passengers and crew.

All American's water "squeezing" principle makes the barrier safe, economical and easy to operate.

Engineers interested in carrying out "impossible" ideas, like "squeezing" water, contact Walt Jones, Personnel Manager, All American Engineering Company, Box USS 2668, DuPont Airport, Wilmington 5, Delaware.

RESEARCH • DESIGN • MANUFACTURE

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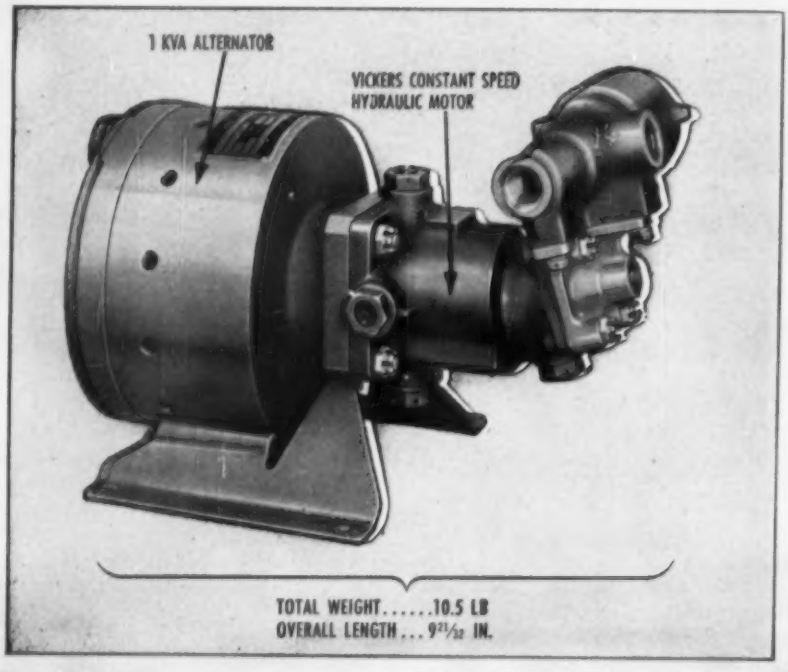
New Vickers Airborne Electrical Power Package

. . . *Saves Weight and Space*

Utilizes the Hydraulic System for More Efficient Production of AC Power



This new isolated electrical power package provides closely regulated AC power with minimum weight and envelope while drawing its power from a hydraulic system. In new designs or when adding electronic equipment to aircraft designs in which the electrical system is already loaded to capacity, this versatile package provides the needed AC power from flow available in the hydraulic system. This generally is permissible without system change as the full flow is seldom demanded except for a few seconds under rare circumstances. Even in such cases, full flow can be guaranteed to these hydraulic functions through the use of a simple priority valve which starves the AC power package momentarily.

Less Weight and More Efficient

Important weight savings are achieved through the use of this package instead of an inverter which may also require an increase in the DC generator and line capacities. In one instance, the 10.5 lb 1 kva package replaced a 38 lb inverter for co-pilot instrumentation. An additional advantage is that the package has 62% overall efficiency while that of the inverter was 35-40%.

Extreme altitude operation is no problem as the Vickers isolated electrical power package contains no brushes or other altitude-sensitive components.

Features of AC Generator

The permanent magnet type AC generator has excellent life and reliability. It requires no bulky voltage regulator . . . is inherently smaller and lighter than conventional generators due to the elimination of the exciter and slip rings. It also has higher overall efficiency resulting from elimination of all excitation losses. Additional advantages are that the permanent magnet is unaffected by momentary short circuit, or separation of field and armature without keeper, or by temperature cycling. It is also not susceptible to aging or shock. This unit is 120/208 volt, three phase, wye connected with 400 cps at 8000 rpm. It is capable of continuous duty under environments of 0-55,000 feet altitude and ambient temperatures from −65 F to 250 F.

Hydraulic Motor Drive

The generator is directly driven by a Vickers Constant Speed Hydraulic Motor having fixed stroke and an integral flow control valve that maintains an 8000 rpm speed setting within ±2½% regardless of the load (as long as valve inlet pressure is greater than load requirement). For the unit shown above, maximum operating pressure is 3000 psi while rated output of 1 kva requires operating pressure of 2200 psi. Special configurations will maintain 400 cps frequency within ±0.1% regardless of load. This motor has a very high horsepower-weight ratio and its overall efficiency exceeds 92%. It is a time-proved design capable of many hundreds of hours of continuous service without attention.

Many Uses and Sizes

The applications for this isolated power source are numerous. For multi-engine aircraft, its use for co-pilot instruments provides dual reliability. This package has been used to supply controlled frequency AC power in emergencies when the only source of power in the airplane is a ram air turbine driven pump. The efficiency of this arrangement minimizes the size and weight of the ram air turbine necessary to provide emergency hydraulic and electric power.

Now available in the sizes listed below, larger packages can also be supplied from existing components. Vickers is prepared to develop the package best suited to a specific need. For further information, get in touch with your nearest Vickers Aircraft Application Engineer.

Vickers Airborne Electrical Power Packages

kva output	weight, pounds
0.5	7.0
1.0	10.5
1.5	12.5
2.0	15
2.5	17
3.0	19

Larger capacities with minimum weight are available.

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2-R

beams fitted to the front wing spar, close to the front wing fittings.

Ammunition boxes provide 150 rounds per gun.

Wing auxiliary armament (attack model) includes the following:

- **Two 500 lb. bombs.**
- **Two 715 lb. napalm tanks.**
- **Two guns** weighing 500 lb. each, on nacelles.
- **Twelve** 3 in. rockets.

The bombs, napalm tanks, or the gun nacelles are hung from faired cross-beams which can be hooked under the wing, in line with the boundary layer fences.

The gun nacelles are designed to include the gun and related ammunition box. The ejection of the link and cases is left free and there is no possibility of interference with the tail surfaces, because of their outboard position.

If 30 mm. Aden guns are used, the ammunition box contains 160 rounds.

The rockets are mounted in four groups of three, two from each outer wing in the area between the landing gear axis of rotation and the wing fences.

Grounding Lifted for RAN Sea Venoms

Melbourne—Some of the Sea Venom aircraft of the Royal Australian Navy have been allowed to resume flying but this is taking place on a greatly restricted scale.

The grounded aircraft are not allowed to be launched by catapult and their usefulness is considerably reduced. Details of modifications are still unknown.

Royal Australian Navy is trying to silence the unfavorable publicity and is keeping the matter as secret as possible to avoid criticism of having selected an unsuitable plane.

Beverley Air Drops 29,000 Lb. Steel Load

London—Blackburn Beverley four-engine military transport released 29,000 lb. of steelplate by parachute.

The plane was flying 130 mph. at 1,500 ft. when an extractor parachute dragged the load from the fuselage. After the extractor chute fell away, eight parachutes, each 66 ft. in diameter opened. These chutes were released automatically as the load hit the ground.

The drop, at Market Weighton, East Yorkshire, lasted 35 seconds.

Lockheed C-130 dropped a 27,000 lb. single load of iron by extractor and another load of 18 A-22 containers, weighing a total of 29,000 lb., by separate parachute in tests at El Centro, Calif. (AW Aug. 6, 1956, p. 458).

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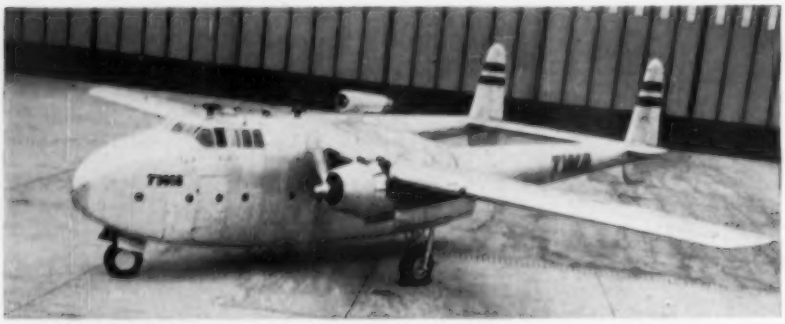
JET-PACKET modified by Steward-Davis Jet-Pak kit flies with both propellers feathered.



TRANS WORLD Airlines uses a single engine for its C-82 maintenance plane.

Turbojets Aid C-82 Performance

Fairchild C-82 "Packet" piston-powered cargo plane, limited commercially by its one-engine-out performance, may be making a comeback through use of an auxiliary jet engine.

Trans World Airlines already is operating a C-82 with its own modification —a Fairchild J44 jet atop its fuselage and a more powerful pair of piston engines. Another modification in the form of kits developed by Steward-Davis, Inc., is being certificated in Mexico and production is expected to begin soon in that country.

The TWA Packet was commissioned at Orly Field, Paris for use as a "flying maintenance base" by the airline. The plane, based at Orly on a 24-hr. alert, will be used to fly TWA engines to any point within 1,000 mi. of Paris. The carrier's overseas maintenance division performed the modification, including addition of the 1,000 lb. thrust jet and installation of Pratt and Whitney R2800CB-3 engines.

Special engine handling equipment such as hoists and stands is being installed in TWA's packet, which also will carry other equipment where needed at the airline's stations in the area. TWA says the plane can be loaded and in the air within 45 min. to carry engines or other items to keep the airline's passenger operation running smoothly.

Steward-Davis, of Gardena, Calif., calls its modification the Jet-Packet and plans to offer two kits, providing for one or two of the auxiliary power plants. Engine is "Turbassist 1600," described as a modernized version of the Westinghouse 19B2B (J30) which powered the McDonnell FH-1 fighter.

According to Steward-Davis, three locations for the two-jet installation were considered: one on each side of the waist of the high-wing airplane; one at each wingtip; and the location chosen, both atop the fuselage.

At waist level, the company decided, propellers would throw rocks and dirt into the jet intake during takeoff. Wingtip jets were rejected as complicated to install and maintain, and because loss of both engines on either side would present control problems necessitating cutting the other jet.

Test flights of the Jet-Packet, Steward-Davis reports, have shown that a C-82 equipped with the jets and loaded to 54,000 lb. will perform with a wide margin of safety during engine-out conditions where a standard C-82

FIVE IMMEDIATE OPENINGS FOR ENGINEERS

Aerodynamics. For responsible assignments in airplane or missile design, particularly for analyses of loads and flying qualities for elastic airframes. Analytical work in hypersonic aerodynamics or mathematical analyses of a variety of aerodynamic problems.

Wind Tunnel (Instrumentation). For responsible work with special instrumentation for the 4-foot high speed wind tunnel and wind tunnel models. Degree and at least 3 years related experience.

Automatic Flight Control Systems (Aerodynamics). To conceive, synthesize and analyze autopilot and automatic stabilization systems. Requires background in aerodynamic stability and control, autopilot application and use of analog and digital computers. Degree and 5 or more years experience.

Propulsion. Heat transfer, duct design, fuels, performance.

Structures Design. Stress analysis, materials, weight control, flutter and vibration.

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Supervisor Engineering Personnel
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Dallas, Texas

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on opening for_____

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City and State_____

A Vought Vignette

NO. 4 IN A NEW SERIES

The Aerodynamicist Who Test-Hopped Equations

There'd never been a fighter that could barrel at more than 1,000 mph one minute and land on a carrier the next. And, as a result, there was unusually keen advance interest in the flying qualities of the airplane proposed by Chance Vought.

Jim Madden was more than curious. As an aerodynamic design specialist, he would help develop the Crusader's handling qualities. His job began with wind tunnel tests.

Jim converted tunnel information into a graphic picture of static and dynamic forces affecting Crusader stability. He used analog computers and equations of motion to predict the build-up of forces during maneuvers. Hinge moments, loads, and required rates of control motion were determined and released to Servomechanism and Product Design groups. Soon the Crusader's stabilization and power control packages began to take shape.

Jim's part in the project could have ended right there. But Vought's control system simulator helped him proceed to some thoroughgoing conclusions.

It duplicated the complete rod system and all servomechanisms that would control the speedy new fighter. In the simulator's cockpit, high above the Structures Lab floor, Jim previewed control responses that test pilots later would experience. Airplane responses to Jim's rudder kicks and aileron movements were recorded on analog computers. Any inability of the control system to position the aircraft during flight was easier to spot . . . and, with test and design engineers on hand . . . easier to correct.

"It was like a big schematic — only better," says Jim of the simulator.

"It gave me a chance to work with the whole system.

"And actually watching aircraft responses to the controls gave me a feeling for how fast they happen."

Another thing that moved fast was Crusader development. Vought's simulator and other facilities detected problems before they compounded. The fighter reached operational readiness in record time.

Research, design and test facilities at Chance Vought allow the engineer to do a thorough job in advanced problem areas . . . assure high reliability in Vought-developed weapon systems.

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40th ANNIVERSARY
1917 TO 1957

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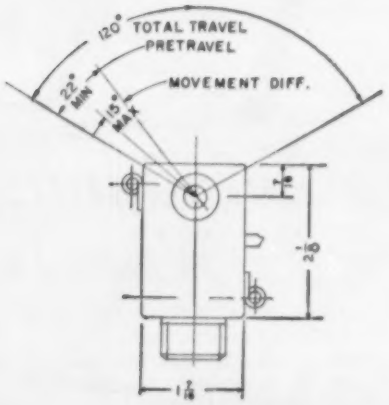
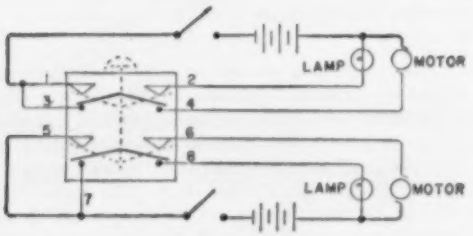
- A seal — not a packing — bonds shaft to case.
- Leakage rate LESS than 1 micron per cu. ft. per hour! Full rating up to 75,000 ft. altitude.
- No-slip splined shaft — adjustable or fixed actuating arm.
- Permits 120° rotary travel — a minimum of 50,000 cycles!
- Long overtravel eliminates need for fine adjustment; permits greater flexibility in linkage action.
- Tough, drawn-steel case. Rigid two-bolt mounting.



TYPICAL CIRCUIT



1-2—Remote lamp indicates when arm is fully returned.
3-4—Motor driving linkage counter clockwise 120°.
5-6—Switch stopped motor at predetermined position.
7-8—Remote lamp indicates arm at full travel position.

The many switching jobs done *best* by rotary-motion limit switches can now be done even better! Electro-Snap's new shaft seal gives you *positive* hermetic sealing, simplifies mounting, saves weight and space, and provides a full 50,000 cycle minimum life.

Elimination of external cranks, cams, links, and other gear to translate rotary to linear motion (as is often done to permit use of hermetically-sealed, lever type switches) reduces weight, space congestion, and the need for tedious adjustment. This simplicity gives you greater freedom in locating interlock and indicating switches on rotary mechanisms; allows positive linkage attachment.

Ice, altitude, rain, or corrosive atmospheres cannot effect this Electro-Snap switch sealed in a dry, inert gas. The steel case protects against shocks; prevents loss of the hermetic seal—also permits tight draw-up on mounting bolts without "springing" the case.

GET FULL ELECTRICAL AND MECHANICAL DATA IMMEDIATELY — WRITE FOR DATA SHEET H10 M-4

ELECTRO-SNAP
SWITCH & MFG. CO.
4252 W. Lake St., Chicago 24, Ill.

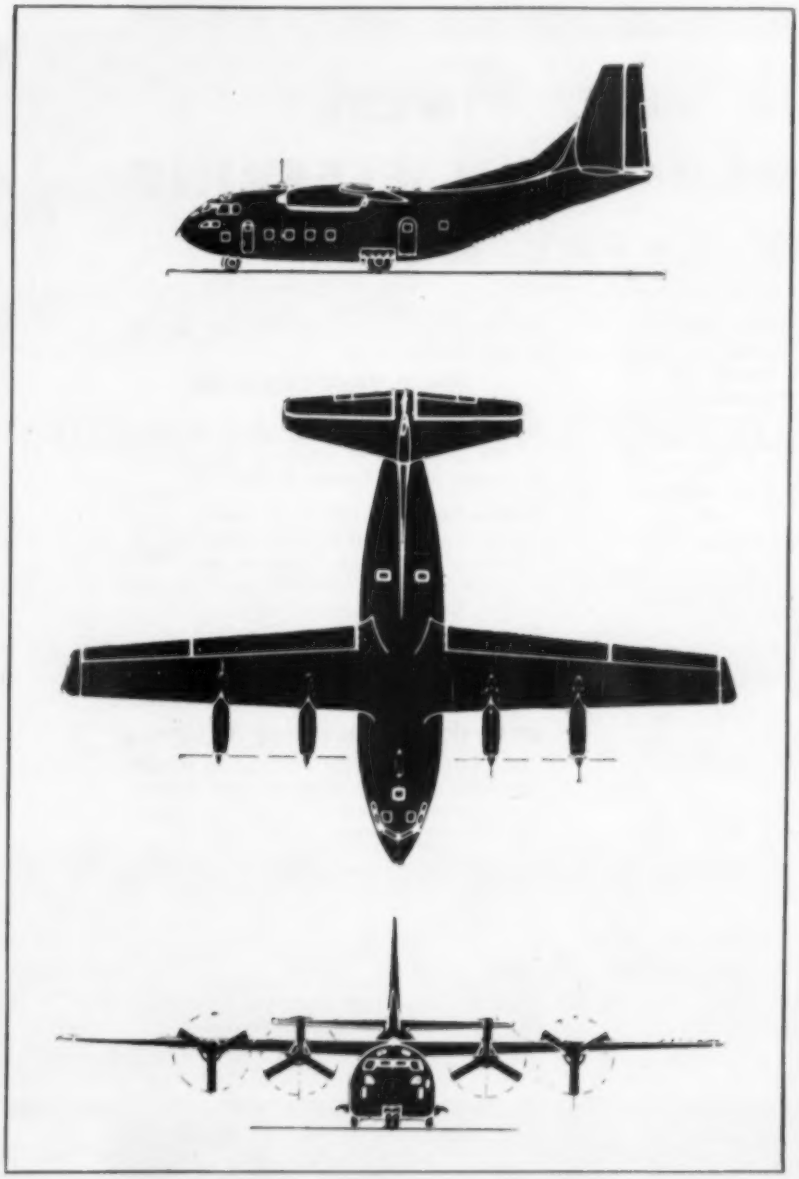
would immediately begin to lose 50 to 100 ft. a minute. Drag of the Jet-Pak is said to cut only 3 mph. from the plane's cruising speed with its piston engines.

Operating procedure with the Jet-Pak calls for firing up the auxiliary engines during final check and running them at METO power during takeoff and climbout. If a piston engine fails during takeoff, the jets are advanced to takeoff power.

Steward-Davis claims the pod modification will cut 28% off takeoff distance needed to clear a 50 ft. obstacle at 54,000 lb. weight (two jets). Kits cost $51,000 with two engines or $26,000 with one turbojet.

They can be installed in 100 man-hours with simple tools, the company told AVIATION WEEK.

Production kits will be made under contract by Servios Aeronauticos de Mexico.



Fairchild Turboprop Transport

Four turboprop engine successor to C-119 and C-123 is planned by Fairchild Engine and Airplane Co. Prototype of the airplane, designated the "Turboboxcar," will use Lycoming T55 engines. Boundary layer control is expected to reduce normal takeoff distance from 2,240 ft. to 1,750 ft. Airplane will gross 75,000 lb. on takeoff, carry 32,181 lb. payload on short hauls (AW April 29, p. 27).

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LOW TEMPERATURE

MIL-I-7444(A)2. This USAF specification is met and exceeded by **Resinite EP-93.** For extreme low temperature use (−90°F) flame and fungus resistant. Approved in all three size ranges.

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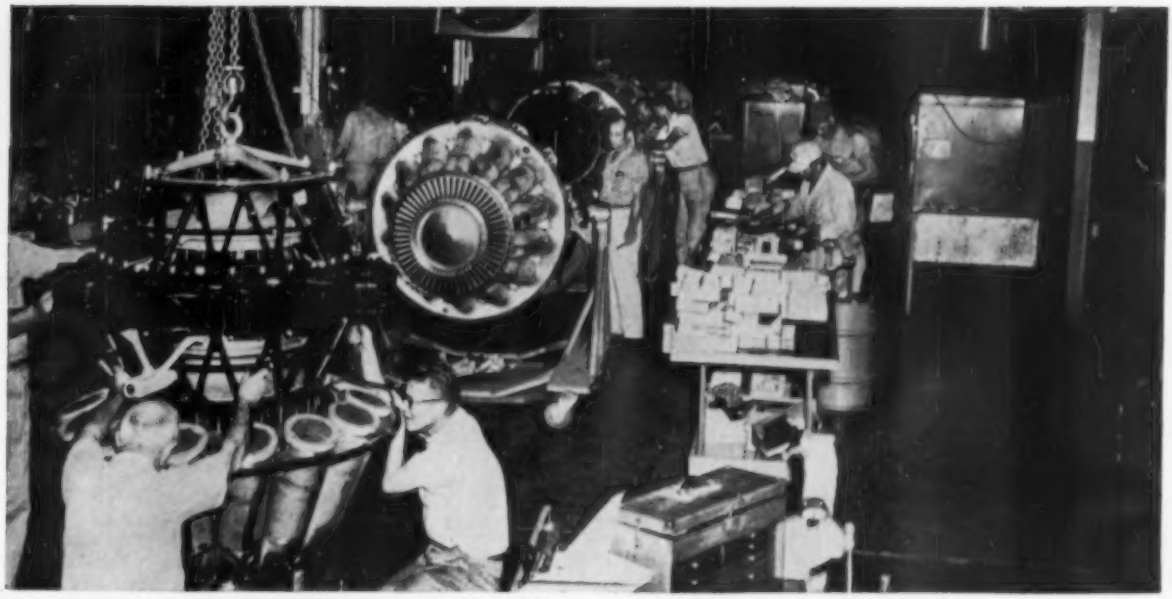


FINAL ASSEMBLY line for Allison J33 engines in Southwest Airmotive engine overhaul shop at Dallas, Texas.

Southwest Enters Jet Overhaul Race

By Craig Lewis

Dallas—Southwest Airmotive Co. is using its experience as an overhauler of military turbine engines to support a sales effort aimed at airline jet overhaul business.

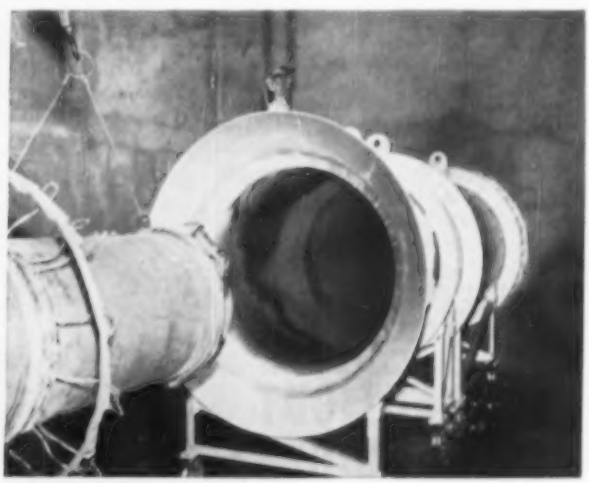
Airlines with an overhaul rate of less than one engine a day are the primary targets for SAC's drive. Such large volume carriers as Eastern Air Lines, Pan American World Airways and American Airlines probably can spread their costs over enough engines to bring prices down to Southwest's level.

Sales efforts are being concentrated on domestic carriers, and all U. S. airlines have been contacted. While SAC has not contacted foreign airlines, the company feels that a foreign carrier with low overhaul volume could pay the price of shipping its engines to Dallas and still save money.

By mid-1959, when the airlines start overhauling jets, SAC will have overhauled more than 6,000 turbine engines for the Navy and Air Force.

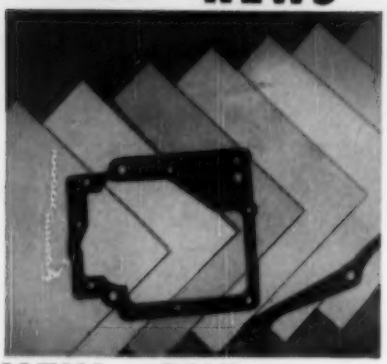
SAC began overhauling piston engines for the military in World War II and got into the jet overhaul business early in 1955 with a $3 million contract to overhaul 1,200 Allison J33 engines (AW Oct. 8, p. 107). After five months and $1.5 million were spent in providing space and equipment for the job, Southwest Airmotive turned out its first turbine overhaul job.

In November, 1956, the company received a Navy contract for J33 overhaul, and J33 production will shortly exceed a rate of 10 engines a day. SAC has also done some modification work.



SAC WELDER works on J33 ring and tube assembly (left). Augmenter tube (right) carries exhaust from jet engine into test cell.

CHR Silicone Rubber NEWS



NEW...CHR fuel resistant silicone rubber COATED FABRICS

Jet fuel, hydraulic and synthetic oil resistance; —85°F to 480°F range.

CHR has added "LS-53"[1] coated glass, "Dacron" and nylon fabrics to their line of COHRlastic® Coated Fabrics.

The new "LS-53" coated fabrics provide vapor, splash and immersion resistance to fuels, hydraulic and synthetic oils over a temperature range of —85°F to 480°F, depending upon base fabric. Supplied on custom basis initially, CHR's "LS-53" coated fabrics provide the most economical use of this new, high performance elastomer.

Many other silicone rubber coated glass, "Dacron," Orlon and Nylon fabrics (for —125°F to 600°F applications other than fuel resistance) are *available from stock* or can be made to order. We will also custom design fabrics to meet specific requirements.

CHR supplies both coated fabrics and finished assemblies made from these fabrics such as actuator boots, aileron curtains, radomes, fuel cells, conveyor belts, arctic covers, fuel and fire barriers, and gaskets.

Write for bulletin describing both "LS-53" and regular silicone rubber coated fabrics.

[1]*Dow-Corning's new fuel resistant fluorosilicone rubber.*

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on the J57 for Ford, but the J33 is the only jet the company has overhauled thus far.

Overhaul work on both piston and jet engines is done in SAC's 115,000 sq. ft. shop at Love Field. With its present volume of business from military and civil customers, Southwest Airmotive doesn't see any need to expand facilities further to handle airline turbine engines. Production volume would be increased by increasing shifts.

Under present contracts, SAC overhauls the J33-A24A for the T2V-1; the J33-A35 for the F-80 and T-33; J33-A33 for the F94 and the J33-A37 for the Martin Matador. Company also overhauls Pratt & Whitney R2800, R2000, R1830 and R985, Wright R1820 and Lycoming and Continental engines.

Isolated Test Cells

Piston engines are tested in cells built into the Love Field engine facility.

The jet engines are tested at an isolated pair of test cells built near Ft. Worth's Amon Carter Field.

The engine work provides a major part of Southwest Airmotive's annual business. The company's sales will exceed $8 million in the year ending May 31, and profits are expected to improve this year after a poor showing last year due to tooling and training costs.

Now celebrating its 25th anniversary, Southwest Airmotive is in the middle of an expansion program that will raise its work force to 750 employees by fall and will provide 300,000 sq. ft. of space by early 1958.

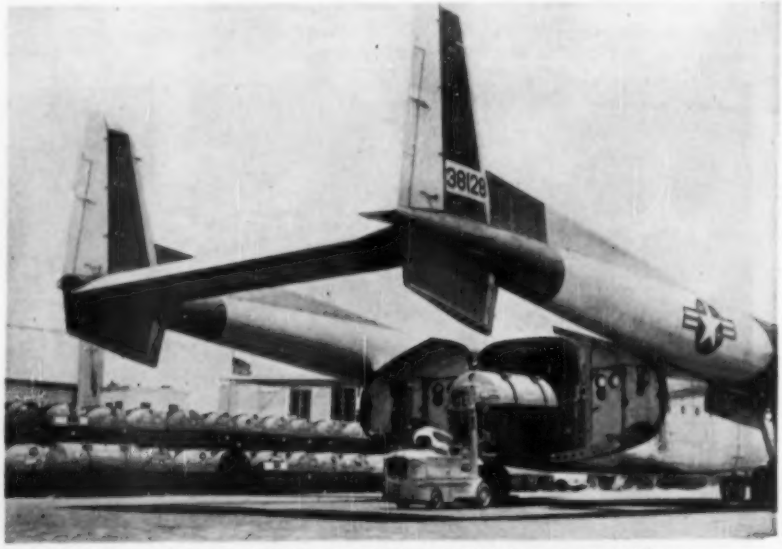
Last year, military sales were 24% of total business and about a third of the service division's 70% share of total volume. Sales Division does about 30% of SAC's annual business.

J33 COMPRESSOR rotor goes through ultrasonic inspection with Sperry Reflectoscope.

Southwest Airmotive's current expansion program was triggered by Dallas' general development program for Love Field. Since the new passenger terminal is under construction on the site of SAC's old service base, the company borrowed $1.5 million from the city's airport bond funds on a 15 year loan to help finance a $2 million base across the field from the old base. The engine overhaul facility isn't affected by the move.

Base Expansion

The new base has 11 acres of ramp space and an 80 x 400 ft. storage hangar. Work on two service hangars and a plush terminal building is scheduled for completion in August. Construction of another two hangars is scheduled for completion early in 1958, giving South-



OVERHAULED engine is loaded into an Air Force C-119 for expedited delivery.

G. D. Schott (center), Flight Controls Department head, discusses a rocket control system with Group Engineer R. A. Fay (right) and F. G. Hudson, missile components research specialist.

FLIGHT CONTROLS THEORY

The transition from theory to reliable components is one of the most difficult phases of flight controls endeavor. At Lockheed Missile Systems Division, engineers and scientists are performing advanced work on a number of theoretical approaches that offer important practical solutions.

Two of the areas are:

- Utilization of feed-back design techniques for optimizing complex dynamic systems
- System verification by analog computer simulation

Significant developments in these and related areas have created new positions at both Sunnyvale and Van Nuys engineering centers. The complex nature of the assignments requires both flight controls experience and the ability to exercise individual initiative. Inquiries are invited.

Lockheed **MISSILE SYSTEMS DIVISION**
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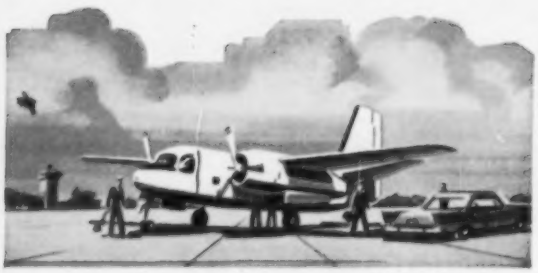

powered by
CYCLONE 9
engines

The U. S. Navy will soon have more Grumman TF-1 "Trader" cargo-passenger planes. These are the aircraft that ferry passengers and cargo between carrier and shore. An initial fleet of these planes has been thoroughly proven in five years of service for the Navy's Fleet Logistic Air Wings. Their short take-off, long range, and high dependability—made possible by Curtiss-Wright Cyclone 9 engines — have made the twin-engined "Traders" indispensable in the rugged all-weather job of carrier resupply.

The Curtiss-Wright Cyclone 9 — one of the world's best-proven engines — is the powerful answer to many special problems and use-requirements in modern aircraft, both military and civil. Powering transports, patrol and rescue aircraft, sub-hunters, trainers and helicopters today, the Cyclone 9 has the longest service background of any aircraft engine type. It is another example of Curtiss-Wright leadership in power for the present and future needs of military and civil aviation.

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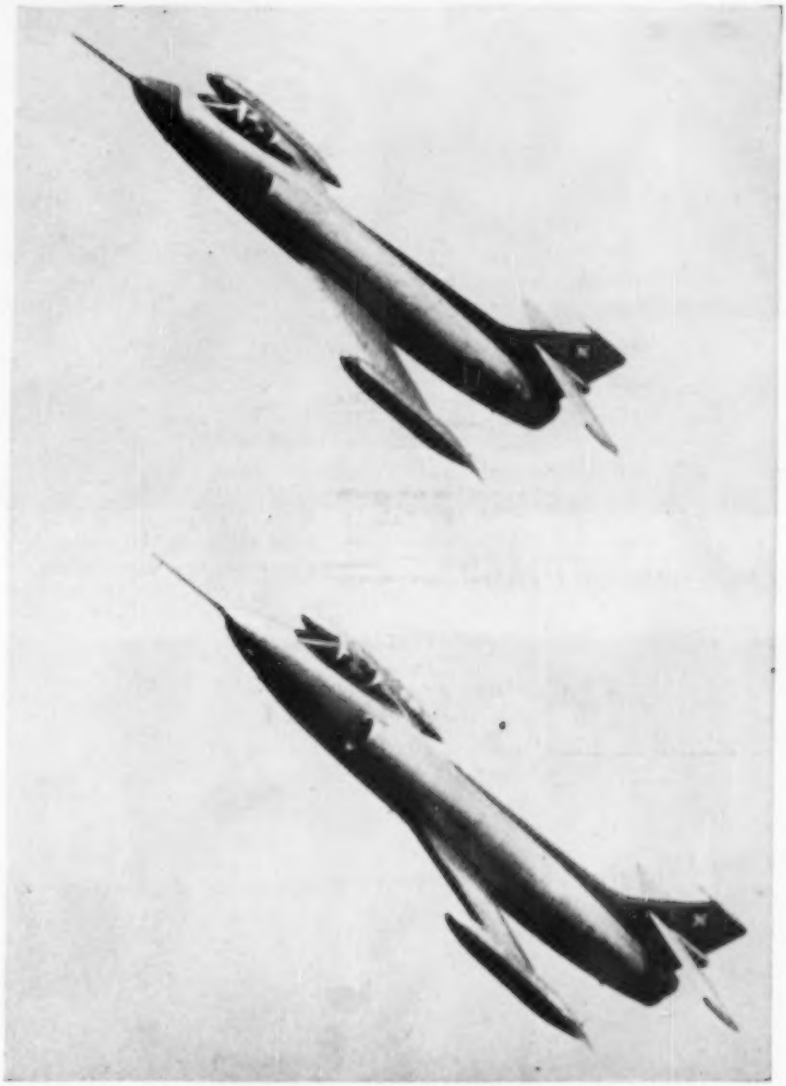


Swiss Fly P.16 Fighters

Second and third prototypes of Swiss-designed and built P.16 fighters, shown in test flight, indicate earlier completion of third model (below) than had been expected. Armstrong Siddeley Sapphire powered fighter is conventional design with large flaps for operating from short, mountain airfields (AW July 4, 1955, p. 35). First prototype was destroyed in an accident. Swiss canceled order for French Mysteres to build own fighter.

west Airmotive an 800 x 160 ft. service building.

With investments of $3.1 million in its engine facility and $150,000 in its sales installation, the new service base will give SAC a $5.25 million installation.

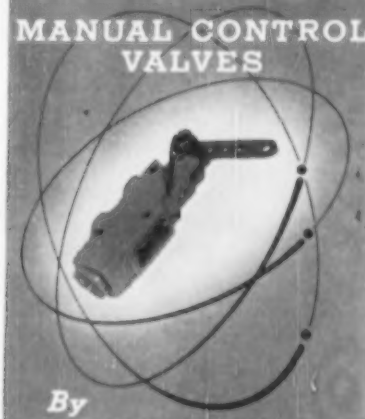
The company also has a $2 million program calling for construction of more hangar space and a distributor sales and general office building within the next five years.

SAC's Service Division is a dealer for Texaco and Magnolia products, and the company provides four octanes of avgas and JP-4. Southwest Airmotive has a contract to refuel transient military aircraft, both propeller and jet. Last year, the company bought six million gallons of fuel for sale and for its own use in testing engines. The new service base has underground storage tanks for 220,000 gallons of fuel.

SAC's sales operations started during World War II, and a separate Sales Division was established at the end of the war. After some disappointments when the private flying boom failed to materialize in the years after the war, Southwest Airmotive has now built its distributor sales volume to a rate of $2.5 million a year, including sales to 12 airlines.

The company is currently distributor

MANUAL CONTROL VALVES



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MC 1888 VALVE – AIR CONTROL, THREE PORT
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FLUID: Air or Nitrogen
PRESSURE RANGE: 0 to 3000 psi
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EXTERNAL LEAKAGE: Zero
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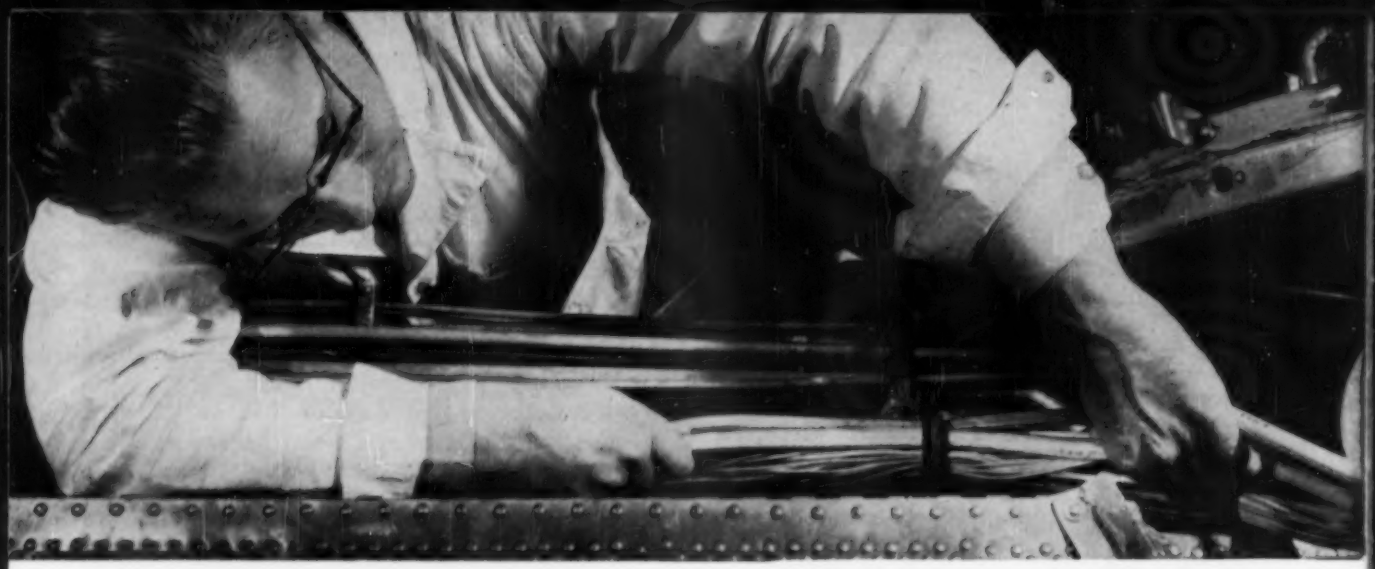

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Whether you're developing a radical new idea in aircraft modification, or simply doing routine rewiring, you're an expert when you use Packard Electric cable. Ask for it by name. It's quickly available in any type, size or color. Packard Electric aircraft cable is sold by leading distributors everywhere.

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Turboprop RC-121, WV-2

Lockheed has presented a firm proposal to the military for a successor to its RC-121 and WV-2 early warning radar planes.

Known as company project CL 257 (AW Dec. 17, p. 23), the aircraft will be an extension of present aircraft in combination; that is, it will have Allison T56 turboprop engines mounted on 1649A Jetstream Starliner wing.

Additional modifications include incorporation of the new saucer radome atop the aircraft which houses a new radar antenna, and generates some lifting surface as well.

One test bed with the saucer dome has been flying for some time, under the designation WV-2E.

Negotiations for sale of the airplane are being held with both Air Force and Navy.

for General Motors' AC Spark Plug Div., Delco-Remy Div. and Packard Electric Div., B. F. Goodrich Co., Aeroquip Corp., Glidden Co., Gould National Batteries, Grimes Manufacturing Co., Jaeger Watch Co., Lycoming, MacWhyte Cable Co., Borg-Warner's Pesco Products Div., A. P. Parts Co., Willard Batteries, United Aircraft's Hamilton-Standard and Pratt & Whitney Divisions and nine divisions of Bendix Aviation Corp.

Russians Find Thrust Rises With Radiation

Russia says it is experimenting with radioactive metals as a means of increasing jet engine thrust.

In reporting on new applications of radiation chemistry discussed at the recent All-Union Scientific Conference on Radioactive Isotopes and Radiation in Moscow, Soviet scientist Nikolai Popov stated:

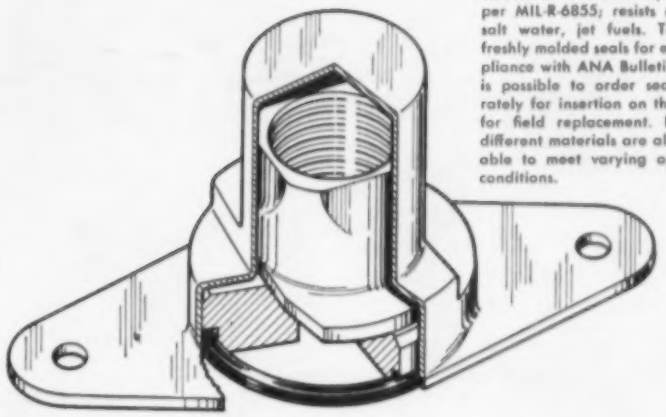
"It has been discovered that quicker and better combustion of the fuel mixture can be achieved if a strong source of radiation is placed near the combustion zone."

"It is very difficult to achieve normal combustion of the fuel mixture in a jet engine without pulsation and discontinuity. Designers have installed a ring made of radioactive metal on the engine nozzle. The radioactive ring emits beta particles—electrons.

Engine thrust has been increased by 10-15%.

University of Michigan scientists are conducting similar experimentation, the most successful using radioactive gold (AW April 22, p. 60).

FASTENER PROBLEM



Sealing ring of new ESNA type A2500 nut meets all requirements per MIL-R-6855; resists gasoline, salt water, jet fuels. To insure freshly molded seals for easy compliance with ANA Bulletin 410, it is possible to order seals separately for insertion on the job or for field replacement. Rings of different materials are also available to meet varying operating conditions.

Leakproof self-locking fasteners for integral fuel tanks

Aircraft designers have eyed the space-saving possibilities of "Wet Wing" or integral fuel tanks for some time. But . . . the "wet" section of the wing must be fastened in such a way that highly volatile aviation fuels will not leak under the base of the tank fasteners or seep out along their bolt threads.

ESNA has just developed the first completely practical answer to this problem. The new ESNA type A2500 floating anchor cap nut (see diagram) is a self-locking anchor nut with an "O"-ring seal in its base. In tests, the nut has maintained a perfect seal against pressures above 50 psi on either side, regardless of structural strain, vibration, or temperature changes. The seal is effective whether the bolt is installed or not. It is not destroyed by repeated bolt installations.

The type A2500 is the lightest nut of its type; 100 nuts weigh only 1.2 pounds. It meets AN-N-5 specifications for operation between −80° F. and +250° F. and can be used for extremes beyond these limits by varying its component materials such as the "O"-ring. It provides .050-inch maximum floating action allowing quick assembly in spite of slight misalignment of bolt holes. *The A2500 is 100% seal tested prior to shipment.* The basic design has been approved by the USAF. Sizes range from 10/32 through sizes 1/4-28, 5/16-24, 3/8-24, and 7/16-20. A gang channel strip providing a series of regularly spaced A2500 nuts has also been designed.

The new Boeing 707 Jet Transport is among the first aircraft equipped with integral wing fuel tanks fastened with the new ESNA type A2500 leakproof nut.

MAIL THE COUPON FOR DESIGN INFORMATION

ESNA

Elastic Stop Nut Corporation of America
Dept. N73-350, 2330 Vauxhall Road, Union, New Jersey

Please send me the following free fastening information:

☐ Details on A2500 nut
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11 famous airlines* have chosen the superb Boeing 707–to fly you in unbelievable comfort and quiet at 600 miles an hour.

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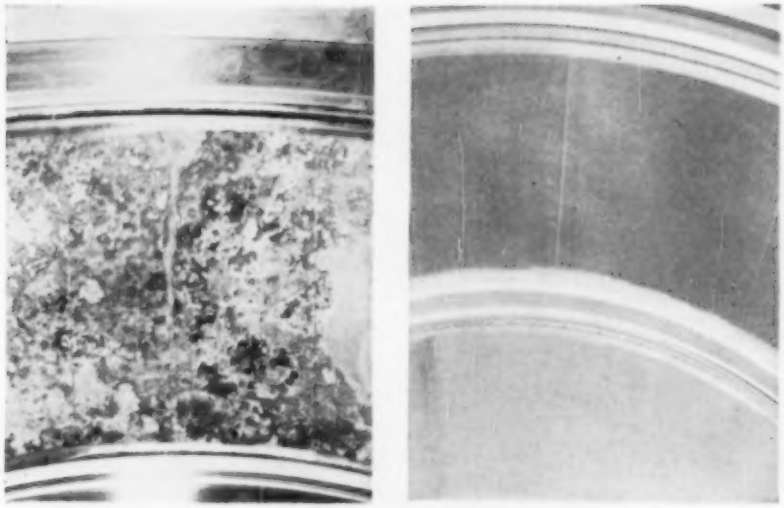
BOEING 707



J57 COMPRESSOR case before (left) and after (right) descaling by Temco process.

Electrolysis Cleans Titanium

Dallas—A new electrolytic process for more efficient descaling of titanium has been developed by Temco Aircraft Corp.

Temco figures it is saving $5,000 a month with the new process, mostly by cutting the rejection rate on titanium parts for military aircraft components built under various subcontracts.

Process descales titanium parts by treatment in an electrolytic acid bath. It was invented by John J. Dailey, supervisor of Temco's Materials and Process Laboratory, and a patent was issued for it earlier this year.

Cleaning Need

Need for an efficient means of cleaning titanium and its alloys stems from the metal's habit of forming oxide scale when heat is applied during forming operations or stress relieving treatment. The scale discolors the metal and makes visual inspection of parts unreliable since cracks and other imperfections are hidden by the scale and tracable only by X-Ray.

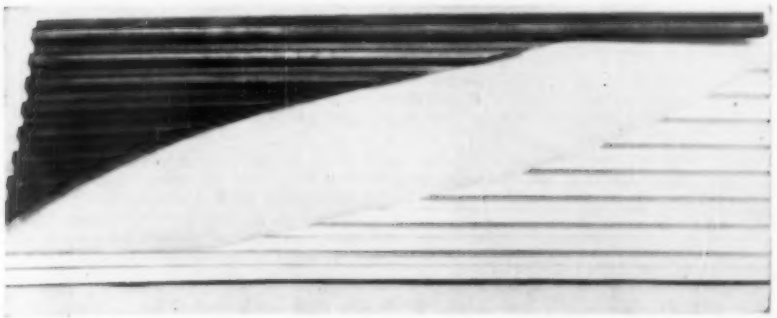
Previously, titanium has been descaled by nitric-hydrofluoric acid bath, molten salt bath or various forms of abrasion. For several reasons, these techniques are cumbersome and costly, and they often result in damage to the metal.

Ti-Brite

In 1954, Dailey developed a new process, now called Ti-Brite, which removes oxide scale by electrolysis. It works on titanium parts of almost any size or shape and removes scale which forms under heat treatment in the temperature range of 400 to 1,300F.

In this process, the titanium part is connected to a cathode lead from a direct current source and is immersed in an electrolytic solution. The solution is composed of 1% by volume of a 48 to 70% solution of hydrofluoric acid, 4% of 38-46 deg. Be. nitric acid, 20% of 60-66 deg. Be. sulfuric acid, 75 deg. water and 3-5 oz. of ferrous sulfate or aluminum sulfate per gal.

A titanium anode is suspended in the electrolyte, and an initial flow of current is applied for one to three

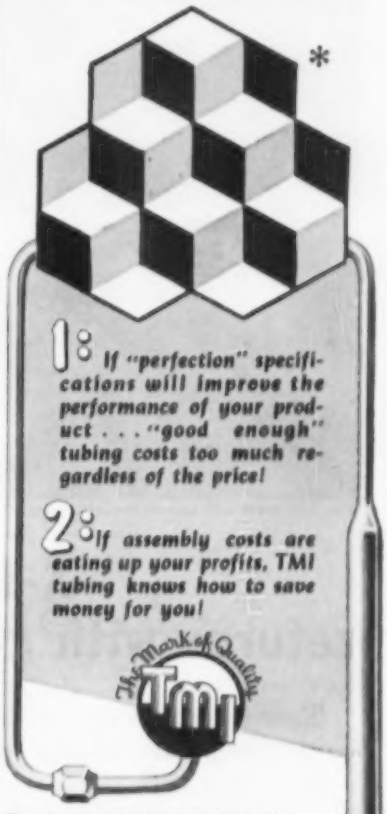


BRIGHT section of F-101 tail section has been descaled. Top has oxide coating.

IT PAYS TO TAKE A

"Second Look"

AT THE QUALITY IN THE TUBING YOU'RE USING!



1: If "perfection" specifications will improve the performance of your product . . . "good enough" tubing costs too much regardless of the price!

2: If assembly costs are eating up your profits, TMI tubing knows how to save money for you!

The Mark of Quality TMI

The "second" look is typical of alert management and pioneering engineers. They know by experience that "yesterday's" quality standards leave much to be desired. In the small diameter stainles steel and special alloy tubing field, TMI is setting the pace . . . and serving the best. There's a reason!

*six blocks? seven blocks? ...it depends on your point of view.

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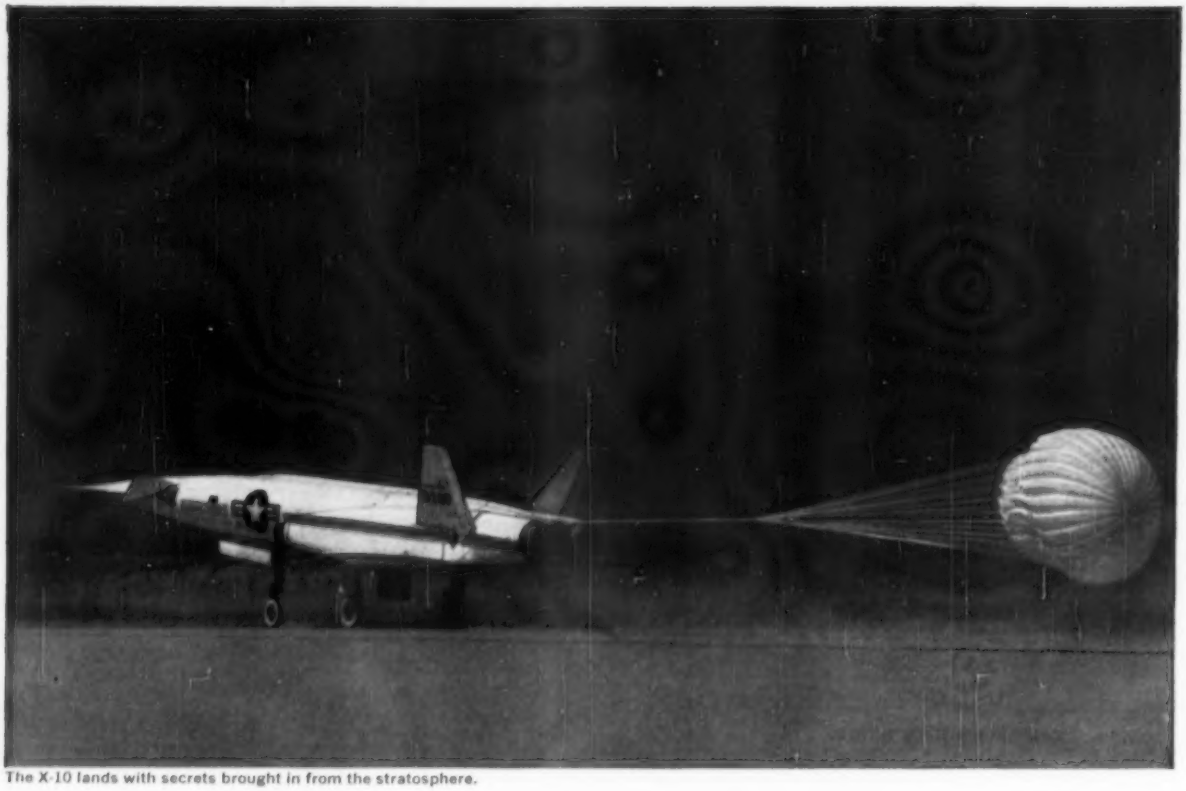
MANUFACTURERS • METALLURGISTS • ENGINEERS SPECIALISTS IN TUBING, .050 to .625 WITH TOLERANCES TO .001 WHEN REQUIRED



The X-10 lands with secrets brought in from the stratosphere.

X-10 missile test vehicle returns with good news for electrical engineers

New scientific data allows the Navaho Missile to leapfrog many R & D steps — go direct into advanced stages. Unprecedented success of the supersonic X-10 spells out this significant fact: The Navaho—an intercontinental strategic missile completely automated and constantly guided throughout its supersonic flight by self-contained control systems—is one of America's *most advanced* missile systems.

This news is important to you—whether you are a 10-year veteran or a recent BSEE. Why? Because now you can start at the very top of missile technology—and reap the rewards of being with a years-ahead company.

40 immediate career opportunities in electronic systems analysis

In Missile Engineering you'll investigate applications of automation that are literally strides ahead of the field. You'll pursue them in pre-flight, preparation, checkout, fueling, countdown and firing. You'll work on "in-flight" control and guidance systems so precise that even the environment within the missile must be rigidly controlled.

One of our immediate needs is for electrical engineers—especially those qualified in systems analysis, systems evaluation, component design and ground checkout. No matter what your experience has been it can be useful to us.

For complete details on these—and other engineering openings—please write: Mr. R. L. Cunningham, Engineering Personnel Manager, Dept 495W5, Missile Development Division, 12214 Lakewood Blvd., Downey, California.

MISSILE DEVELOPMENT DIVISION

NORTH AMERICAN AVIATION, INC.

minutes at a DC voltage of from 6 to 36 volts. Current is reversed for one to three minutes, then is reversed again so current is flowing in the original direction.

Treatment is continued with the titanium part as the cathode until scale is loosened or removed. The period usually varies between five and 30 minutes.

The parts are then rinsed in a running water bath. Both the electrolyte and the water bath are room temperature.

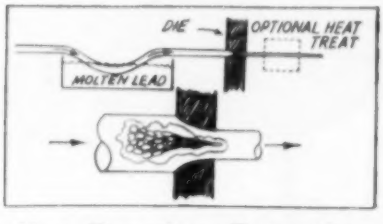
Temco says the process leaves titanium parts with a smooth, natural surface and causes no gage loss. Older methods often etched the metal, scratched it or reduced gage.

Elimination of expensive installations and hand labor are cited by Temco as advantages of the new electrolytics process. With Ti-Brite, Temco uses one man to handle an operation that formerly required eight and involved a great deal of hand-scrubbing of parts between immersions in acid pickle.

Most important saving in the process lies in the reduction of titanium parts rejection because of damage in descaling. According to the company, the electrolysis does such a delicate job that machining marks are still visible on the metal after it is descaled. Most titanium parts cleaned by the new process are for Temco's work on F-101 tail sections and J57 engine components.

After the process was developed in 1954, the company ran a pilot tank for about a year. In 1955, a 450 gal. tank was installed to handle production work.

A new 1,100 gal. tank was installed in January and has handled descaling of all production titanium since then.



Hot Drawing Extrusion Raises Fatigue Level

Hot drawing manganese steel produces a uniform, 140,000 ultimate tensile strength "fatigue-proof" extrusion according to the La Salle Steel Co., Chicago, Ill. The steel is heated in a lead bath to a temperature between 200F and the critical point and then reduced 30-40% in carbide dies. While the dies flatten out the crystals, the temperature age hardens the steel by nitride and carbon precipitation.

ACCURACY!
Each month, hundreds of Whittaker gyros are used in the missiles which are so vital to our nation's defense. Accuracy in this project is of critical importance. Whittaker gyros meet these requirements with a rejection rate of less than 2%. Whittaker Gyro will be pleased to place its experience and facilities at your disposal.
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DIVISION OF TELECOMPUTING CORPORATION
VAN NUYS, CALIFORNIA
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SERVICE STEEL • DETROIT, MICHIGAN LOS ANGELES, CALIFORNIA

To speed up the "Hustler"

we slowed down the Air!

How the Honeywell Engine Inlet Diffuser Control adds hustle to Convair's supersonic B-58 "Hustler."

As Mach numbers go up, engine thrust can be reduced tremendously by even fractional errors in the positioning of inlet air diffusers. To get maximum thrust, inlet air must be slowed down with minimum drag and maximum pressure recovery.

That's why the B-58 relies upon Honeywell Aero's Engine Inlet Air Diffuser Control, one of which is installed in each engine nacelle. They automatically control the diffuser configuration to permit maximum engine thrust at all speeds and flight conditions.

Without this Honeywell system the "Hustler" might never reach its maximum supersonic hustle.

Aiding Honeywell in the design and production of such advanced aeronautical control systems is a history of achievement which includes: over one quarter million of the world's most accurate gyroscopes; more flight control systems than any other company has produced; fuel gages for every type of plane; controls and components for all types of aircraft propulsion systems.

Honeywell

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Engineers! Two hundred and eighty advanced projects are now in progress at Honeywell Aero. *You* can guide one of them from development to release stage, direct your own team of technician, model maker, evaluation engineer and draftsmen. You'll get quick recognition and advancement at Honeywell. Your first-rate salary is just the start. If you're a design-development or production engineer, send your résumé *today* to Bruce Wood, Technical Director, Honeywell Aero, Dept. TA1J, 1433 Stinson Blvd. N.E. Minneapolis 13, Minnesota.

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Choose your assignments in • Airframe design • Weight control • Power plant installation (jet and reciprocating) • Airframe stress analysis • Jet propulsion • Production liaison • Technical illustration • Catalog & Maintenance writing • Engineering checking. Contact: Professional Placement Supervisor, Department AW.

Cessna

CESSNA AIRCRAFT COMPANY • 5800 EAST PAWNEE • WICHITA, KANSAS

TAPE-PROGRAMMED milling machine will be used by Martin Co. in P6M SeaMaster and Matador missile production. Machine was developed by Bendix Aviation Corp., will provide first production application of the principle.

Tape Milling to Cut P6M Lead Time

Martin Co.'s new tape-programmed profile-milling machine, first production application of its kind, will cut weeks off lead time in production of P6M SeaMaster rotary mine door fittings, the company reports. It will also be used in Matador missile production.

Machine uses signals from punched tape which guide cutting head over the work.

Time Saving

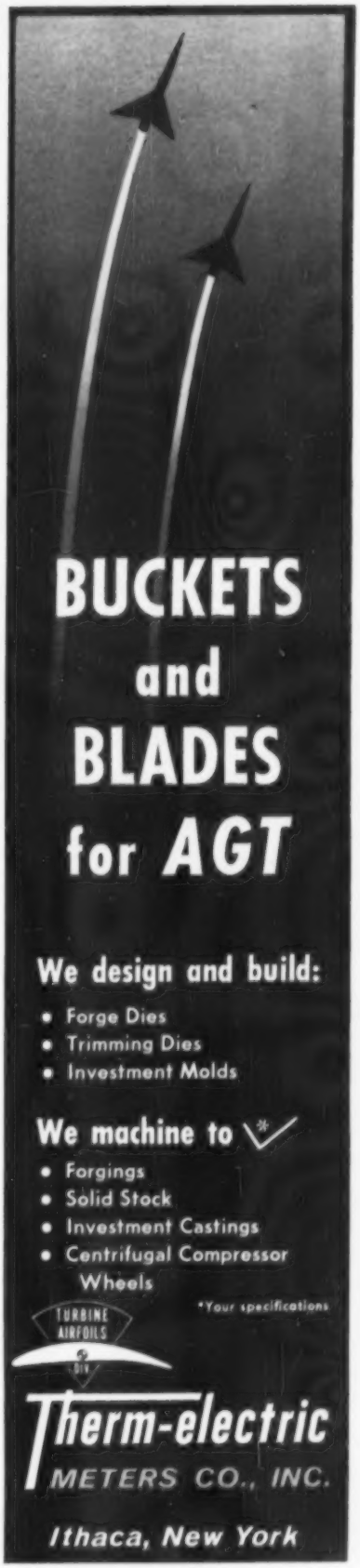
Saving in the door fitting time will be made possible by taking geometry in the form of numerical descriptions off the engineering drawings and, after suitable translation into the machine's language, programming the machine to mill a finished part. Previous intermediate step of hand made pattern or model from mold loft template is said to be eliminated. The numerically-controlled machine, which was engineered and produced for Martin by Bendix Aviation Co., is said to have the inherent speed and accuracy to mass produce complex parts of supersonic aircraft frames during national emergency crash programs.

Several benefits are claimed for this type of tape controlled three-dimensional machine. Shapes which are according to engineering standards can be stored for simple call-ups as they are needed. Engineering changes can be accomplished by splicing in new tape sections.

At times of national emergency second manufacturing sources for weapons systems can be rapidly tooled by merely sending out duplicates of the master tape.

Part Capacity

Size of parts which can be handled by the 50 ton machine is said to extend up to whole aircraft wings. As an example of the time saving which can be realized by the underlying principle, Bendix cited a small master cam for a jet engine fuel metering system. Five to ten weeks of highly skilled work were reduced to 2-4 days by an earlier version of the tape controlled process.



400°F

new synchro

- 250 hour life at 400°F.
- Unprecedented −65°F to +400°F operating temperature range.
- Unique lubrication method.
- Special alloy for electrical connections.

Type 11-4133-01 is a size 11 torque transmitter synchro with 115V 400 cycle input. Accuracy is ±15′, null voltage 175 mv, stator output 90 volts and phase shift 6.5°. Impedances are $Z_{RO}=315+J1590$, $Z_{SO}=290+J773$ and $Z_{RSS}=520+J286$.

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Other products include actuators, servos, AC drive motors, servo mechanism assemblies, DC motors, motor-gear-trains, fast response resolvers, servo torque units, reference and tachometer generators and motor driven blower and fan assemblies.

F-100 Rolls For Camera

North American F-100D Super Sabre is photographed for the first time performing a slow roll. Photographs were taken from the tail gun slot of an Air Force B-45 Tornado bomber. The plane was flown by George Matteson, North American chief production pilot. Sequence runs from top left to right.

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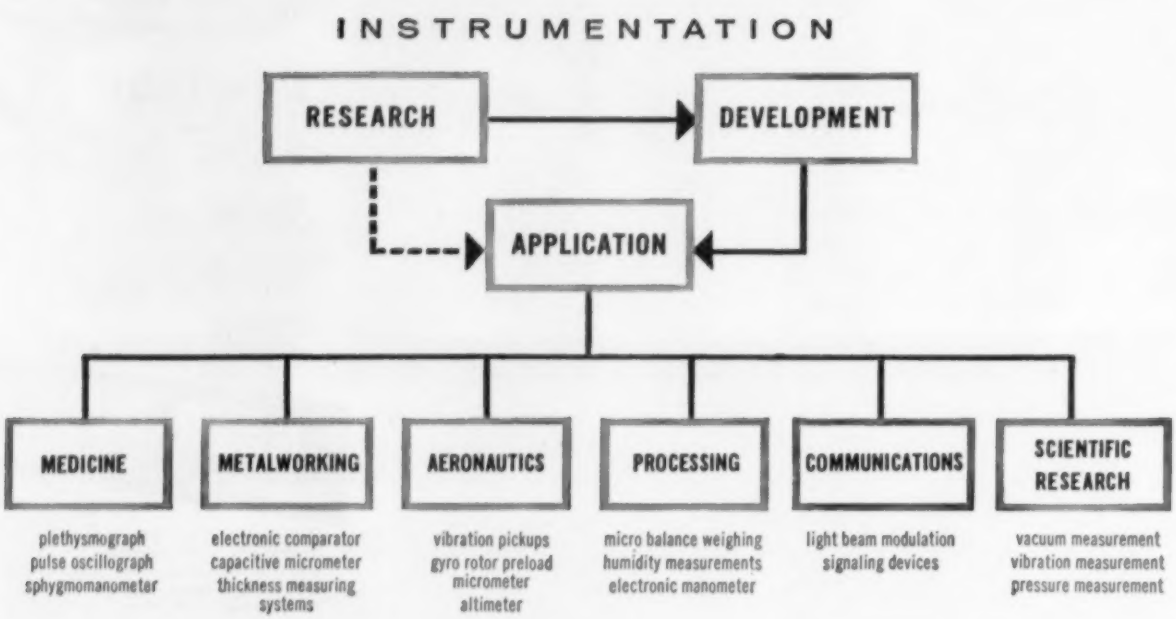


an idea is the solution to every problem

Decker Aviation is a company of ideas.

Not long ago, for example, Decker took the idea of an ionization transducer and brought the idea to reality . . . then used it imaginatively to solve pressing problems in any number of far flung fields.

In medicine, Decker applied the transducer to the improvement of such basic instruments as the plethysmograph . . . giving medical researchers a new magnitude of sensitivity in their explorations.

For geophysical research, Decker ideas made possible instrumentation that, mounted in the nose of an Aerobee-Hi rocket reaching an altitude of 125 miles, continuously and accurately measured both ram and ambient atmospheric pressures at speeds in excess of a mile per second.

Applying new ideas to the micrometer comparator, Decker gave the production line an instrument for measuring an object without physical contact to within a few millionths of an inch.

All the examples listed on this page hardly begin to show the extent of Decker accomplishments. For one problem after another, we have found the idea . . . developed it into a solution . . . built prototypes . . . even manufactured finished instruments.

We would honor an opportunity to evaluate your problems. Our ideas may very well be their solution.

DECKER AVIATION CORPORATION

Philadelphia

NEW AVIATION PRODUCTS

Switches for Rockets

Precision switch line for use in rocket installation and similar aircraft application are especially designed to resist highly corrosive effect of propulsive gases and adverse conditions found in exposed positions of high-speed, high-altitude aircraft.

Designated 21AS series, switches are high-capacity units attached to rugged cam-type actuator. Basic switching unit is a qualified product under Military Standard MS 24331, the maker notes. Model 21AS1 is a two-circuit double-throw and 21AS2 is a single-pole single-throw.

Micro Switch, division of Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Jet Blast Fence

Air Curtain jet blast fence utilizes simple structural steel framework, heavy-gage corrugated, galvanized steel sheets bolted to a flush concrete pier. Steel sheets are especially curved to deflect blast vertically to dissipate its

energy, prevent blast from spilling over the top of the fence.

A concrete fence of similar characteristics is available for higher temperature powerplants of the rocket type; an inexpensive water-cooled fence is being developed for afterburner and other rocket applications.

Lynn Engineering Co., Russ Bldg., San Francisco 4, Calif.

Reference Junction Compensator

Miniature reference junction compensator measures 1¼ in. x 3 in. x 3⅛ in., weighs 12 oz., and is a bridge type unit which adds to the measuring circuit a third voltage continuously equal and opposite to the reference junction voltage, so that only measuring junction voltages are detected.

Almost any existing voltage sources may be utilized and reference temperatures can be pre-selected below lowest expected measured temperature to prevent reversal of circuit voltage polarity. Unit is potted after assembly in high temperature RTV Silastic–construction being entirely of resistors and other static devices.

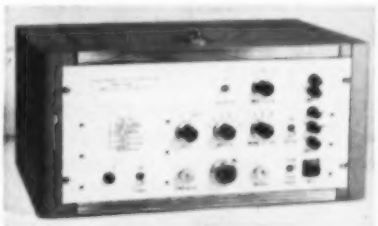
Thermo Electric Co., Inc., Saddle Brook, N. J.

Truck for Liquid Oxygen/Nitrogen

Built to ASME and ICC specification in 500-3,500-gal. capacity, liquid oxygen and nitrogen trailer truck transport units have bottom fill and discharge line, top fill line, quick pressure buildup system, extended stem valves on liquid lines ending with quick couplings. Powder in vacuum insulated equipment is utilized. Builder is Hofman Laboratories, 219-221 Emmet St., Newark, N. J.

Dynamic Strain Analyzer

PA-2A dynamic strain analyzer combines a 400-cycle chopper and amplifier resulting in noise level of about 3 m.v., the manufacturer reports. Amplifier frequency response is flat from 5 cps. to 50 k.c. Any resistive type strain gage may be used. Two strain measuring gages of ± 5,000 and ± 10,000 micro-inches per inch read directly on a 10-turn dial, permitting



accurate peak to peak measurements of dynamic strain. Maintenance is eased by use of a.c. line operation of amplifier.

Polyphase Instrument Co., Bridgeport, Pa.

Magnetic Sweeper for Airports

Sabre-Netic sweeper, designed for military use, is designed to clear airport areas of harmful foreign metallic ob-

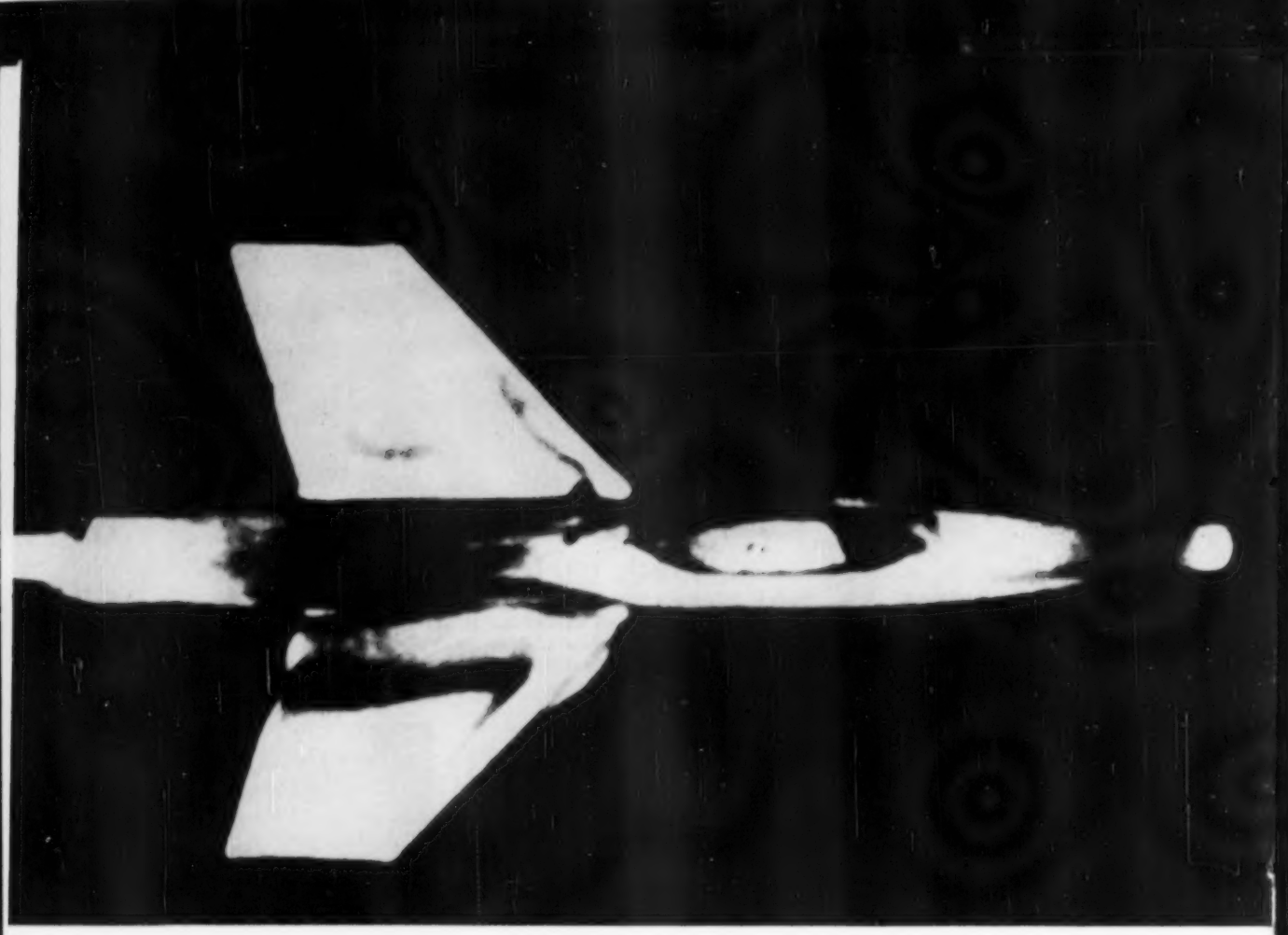
jects. Powered by a Continental engine, equipment can lift a 500-lb. steel plate at 5-7 mph. sweeping speed.

Equipment is also adaptable to snow plowing, grading or as a pulling tractor.

Sabre Metal Products, Inc., 8000 W. 47 St., Lyons, Ill.

Servo System Analyzer

Model F Servoscope measures frequencies as high as 100 cps. and also provides low end coverage at .005 cps. Equipment gives sine, modulated sine and square wave signals in addition to



thermal thicket

The thermal barrier which now limits the speed of ultra high speed aircraft can be cracked. Needed: Structural components of elevated temperature alloys. Problems: Finding the right alloys; making them easy to forge and machine with regular production-line tools; maintaining uniformity of physical properties in production lots.

Right now, Carpenter is producing elevated temperature alloys which set new standards for consistent ability to meet tough aircraft specifications, high quality, improved forgeability and machinability. Engine builders find them ideal for many critical parts. Forge shops can work them to closer tolerances, get better finishes that require far less than usual machining. Work goes faster. Rejects are fewer.

You can get the full story of these alloys — their application, fabrication and engineering properties — in the new booklet, "Carpenter Alloys for Elevated Temperature Service". Get your personal copy by writing on your Company letterhead. The Carpenter Steel Company, 128 W. Bern Street, Reading, Pa.

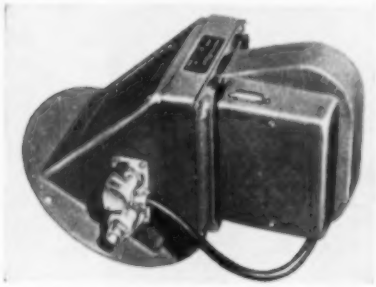
Carpenter STEEL

Improved alloys for elevated temperature service

linear sweep on four ranges from .005 to 100 cps.

Other models accept carrier frequencies from 50 to 5,000 cycles from the same source for the system being tested.

Servo Corporation of America, 20-20 Jericho Turnpike, New Hyde Park, N. Y.

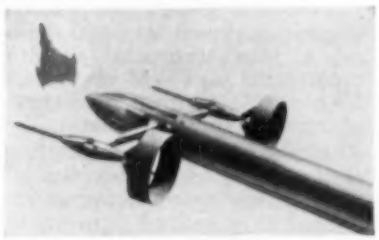


Camera for Computers

Beattie Varitron camera for high-speed read-out with computer and computing systems picks up data directly from cathode ray tube presentation, recording data in small, easy-to-file form. Special field-flattening optics correct image distortion. Micrometer focusing also aids image sharpness.

Camera holds 100 ft. of 35-mm. film, automatically advanced by an electric drive; exposure may be made at predetermined or random intervals.

Photographic Products, Inc., 1000 No. Olive St., Anaheim, Calif.



VTOL Velocity Recorder

Velocity measuring unit that picks up angles of attack and sideslip at low airspeeds experienced in VTOL aircraft is being used by Ryan to record true air velocity vector during transition flight.

Device is a special wind vane with two degrees of rotation. Two identical swiveling heads opposite each other measure airflow direction and pitot static pressure, the heads aligning themselves with external airflow. Unit weight less mounting nose boom is under two pounds.

Task Corp., Anaheim, Calif.

Oxygen Regulator Weighs 1½ Oz.

Miniature oxygen regulator weighing 1¼ oz. and measuring 1¾-in. diameter x ⅝-in. thick, permits user to draw oxygen with normal breathing, manufac-

manhandling the "Hustler" demands instant control response

...PACIFIC REGULATORS maintain constant cable tension for precise control under ALL conditions!

With today's supersonic speeds, faster climbing ability and higher ceilings, the problems of maintaining instantly coordinated control are magnified.

Atmospheric and airframe temperatures vary wider and faster. Structural problems are increased by high speed designs and the increased performance demanded. That's why *automatic compensation* of control cable is increasingly important on advanced performance aircraft such as Convair's new B-58 Hustler.

All the principal cable control systems on the B-58 are Pacific Regulated because these simple, mechanical devices continually compensate for both thermal and mechanical variations in the system—*as they occur!* The same accurate control response is available at all times—under all flight conditions!

In addition, Pacific Regulators allow a significant reduction of the rigged tension of the system because cable tension stays as rigged. This means a reduction in friction and wear in the system, and can also result in a very considerable weight savings.

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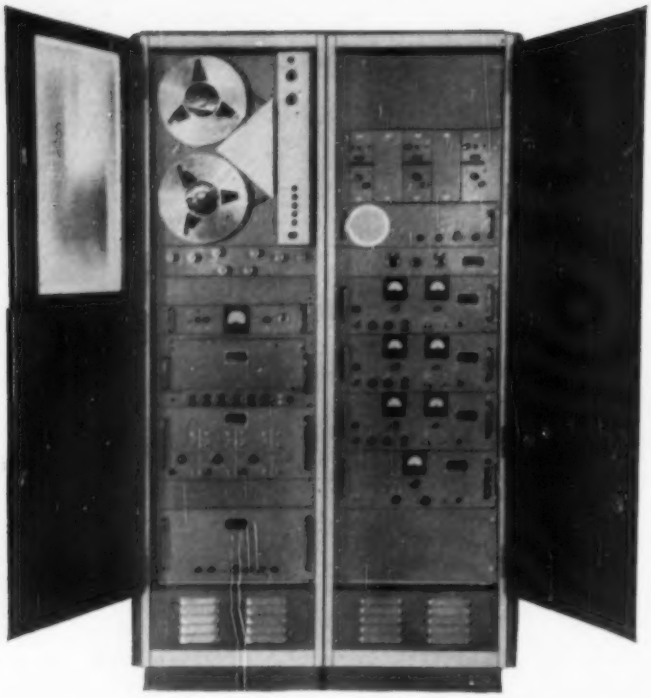

NEW UNIVERSAL SYSTEMS

meet 90% of magnetic tape data recording needs

You get all the precision and accuracy of a custom design *and* the off-the-shelf availability and dollar savings of a "package" design in Davies new Universal Tape Systems.

Every component has been designed to provide maximum flexibility consistent with overall system accuracy. Interchangeable electronics match the system to *your individual requirements* . . . now and for years to come. Specify a Universal System that satisfies your *immediate* requirements . . . adding tracks of data capacity as requirements grow.

Any one of the maximum of fifteen tracks provided can carry data recorded by any one of the three major techniques. Interchangeable Direct, FM, and PWM electronics assure you a *vital* data recording system . . . able to handle each new job as it arises. Standard options are also available to meet the special needs of telemetering and multiplexed data.

Among the features of a Davies Universal Tape System never before available in "package" equipment are six tape speeds at the flip of a switch . . . automatic switching discriminators that match tape speed at the transport . . . precise phase coincidence of data among all tracks . . . and facilities for electronic flutter-and-wow compensation. Every item has been proved through years of service in jets, missiles, and on the ground.

Here's a brief rundown of the options available to you when specifying a Davies Universal Tape System that will grow with your recording requirements:

Transport: Standard transport offers up to six speeds, selectable at the flip of a switch. Precision 10½" or 14" reels available for 1" or 1½" tape. Three-speed transport optional for PWM systems.

Heads: In-line multitrack heads permit up to 15 tracks on 1½" tape, assure precise time and phase coincidence of data among all tracks. Separate record and playback heads provided. Interleaved head stacks permitting up to 30 tracks on 1½" tape, optional for telemetering, other applications not requiring data coincidence.

Direct Recording electronics record and playback data from 100 to 100,000 cps. Ideal for high frequency data, also for recording complex wave forms made up of many frequency multiplexed signal channels. Bandpass type discriminators provided for recovering multiplexed data.

FM electronics frequency modulate a stable carrier with the data, to provide extremely accurate data reproduction, independent of tape variations.

Pulse Width Modulation (PWM) electronics permit up to 90 channels of quasi-static data on each tape track. All PWM electronics are compatible with standard keyers and decoding equipment.

Flutter-And-Wow Compensation electronically eliminates the effects of tape speed variation. Included as standard equipment whenever discriminators are used for data recovery, they can be accommodated by every Universal Tape System. Compensation permits FM channels of a Universal Tape System to preserve a high signal-to-noise ratio—better than 50 db at 30 ips, for example.

COMPLETE INFORMATION *on Davies new Universal Tape Systems, and how they can satisfy your magnetic tape data recording needs is provided in Bulletin 2701. Write for your copy to Minneapolis-Honeywell Regulator Co., Davies Laboratories Division, 10721 Hanna Street, Beltsville, Maryland. Or call Webster 5-2700.*

MINNEAPOLIS **Honeywell**

DAVIES LABORATORIES DIV.

Obtain your Scotch Brand recording tape for all instrumentation recording needs at your nearest Honeywell Industrial Sales Office.

turer reports. Low suction required to open the regulator valve minimizes high-altitude pilot fatigue, virtually eliminates breathing contaminated air as a result of mask leakage incurred by exertion in breathing.

Dual functions also are noteworthy: Regulator operates on a mechanical pilot valve principle and flow with the demands of the user, does not flow during exhalation; with an increase in altitude, a bellows device increases oxygen pressure in accordance with a predetermined breather schedule.

Aeronautical Division, Robertshaw-Fulton Controls Co., Santa Ana Freeway, Euclid Ave., Anaheim, Calif.

Control Force Sensors

Control force sensors, adaptable to standard controls, eliminate break-out friction to permit pilot to command maneuvering rates lower than those possible with manual control, according to the manufacturer.

Stick forces per G and normal "feel" forces may be varied or held constant over the performance range of any aircraft, and artificial dihedral effect may

be included, it is stated. Pilot retains full authority of manual control but may release the controls at any time for other cockpit duties. Units have been tested in several configurations on the Dassault Mystere, F-100 and F-84 jet fighters. Equipment is available for control stick, wheel and rudder pedals.

Lear, Inc., 110 Ionia Ave., N.W., Grand Rapids, Mich.

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RATE GYROS

The R. C. Allen damped rate gyro is the result of fourteen years proven-in-flight precision instrument experience. Now in full production in a new pressurized, air-conditioned plant, the R. C. Allen damped rate gyro has a wide range of applications. The unit is small, efficient and hermetically-sealed. Meets environmental conditions specified in MIL-E-5272A. Requires no heater for damping from .2 to 500 times critical, with temperature compensation from −55°C to +80°C. We will design a prototype for your requirements and send on consignment for your evaluation.

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Write for information on R. C. Allen precision instruments . . . or send us your specifications for a prototype to be sent on consignment.

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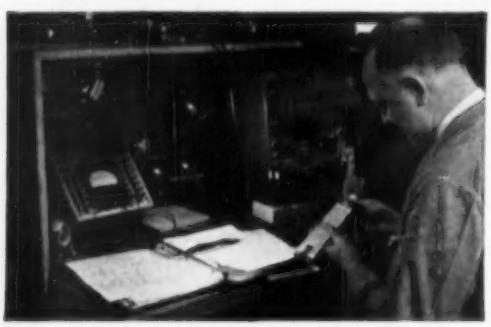
...performance proved for every control surface application

When flutter first became a problem on high-speed, high performance aircraft, Houdaille launched an intensive research program to develop high frequency flutter damping devices. Today Houdaille offers a wide range of designs in both rotary and linear types, to meet any control surface application . . . any envelope requirements.

Houdaille Flutter Dampers are completely self-contained, precision-built hydraulic mechanisms specified by leading airframe manufacturers for their dependability and performance. Normally supplied with MIL-O-5606 fluid, available at all operational bases, they may be furnished with the new high-temperature fluids when specified. A thermostatic valve assures uniform damping characteristics over a temperature range of −65° to 300°F and above.



CONTINUOUS TESTING and rigid quality controls are standard procedure at Houdaille. Production dampers must undergo exhaustive tests for several days on equipment such as this, to make certain each unit meets all phases of the customer's specifications.

WRITE FOR TECHNICAL BULLETIN giving complete performance and operational data. For engineering assistance on flutter damping applications at the aircraft design stage, contact Buffalo Hydraulics Division, Dept. AW.

• Several individual engineering opportunities are available in complete product creation. Interviews are invited.

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WHAT'S NEW

Publications Received:

Realities of Space Travel—Ed. by L. J. Carter—Pub. by Putnam & Company, Ltd., 42 Great Russell St., London, WC1, England. Approx. $5.00; 431pp.

Selected Papers of the British Interplanetary Society which present the known facts about travel in outer space.

Aircraft of the Royal Air Force 1918-57—by Owen Thetford—Pub. by Putnam & Company, Ltd., 42 Great Russell St., London WC1, England. Approx. $7.00; 528pp.

Encyclopedia of all aircraft which have served with the Royal Air Force since its inception on April 1, 1918 to the present day.

Nuclear Power Engineering—by Henry C. Schwenk, Henry Pratt Co.; and Robert H. Shannon, United Engineers and Constructors, Inc.—Ed. by B. G. A. Skrotzki of Power Magazine—Pub. by McGraw-Hill Book Co., 330 West 42nd St., New York 36, N. Y. $6.50; 344pp.

This book, planned for engineers, technicians, and executives concerned with practical power development, gives a clear explanation of nuclear power plants—design, construction, and operation are described in one convenient volume.

U. S. Aviation Today—Pub. by the National Aviation Educational Council, 1025 Connecticut Ave., N. W., Washington 6, D. C. $.35; 94 pp.

Detailing the latest aircraft, missiles, and avionic equipment, this booklet presents the achievements in aviation during 1956.

The Gee Bee Story—by Charles G. Mandrake—Pub. by Robert R. Longo, 1318 Beaumont Drive, Wichita 4, Kansas. Over 106 pp.

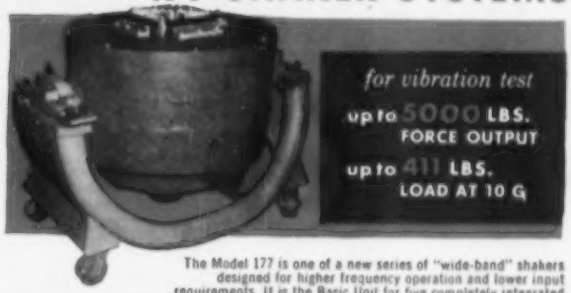
This is the story of the Granville Brothers, their aircraft, and their contributions to aerodynamic engineering. Liberally illustrated.

Automation: Its Purpose & Future—by Magnus Pyke—Pub. by Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. $10.00; 191 pp.

As its title indicates, the book describes the advent of automation, currently automatic processes in various industries, and the factors affecting the speed with which it is likely to spread in different countries.

High Speed Flight—by E. Ower and J. L. Nayler—Pub. by Philosophical Library, Inc., 15 East 40th Street, New

NEW CALIDYNE 177 SHAKER SYSTEMS



The Model 177 is one of a new series of "wide-band" shakers designed for higher frequency operation and lower input requirements. It is the Basic Unit for five completely integrated CALIDYNE Vibration Test Systems. Oscillatory linear forces up to 5000 lbs. are generated and precisely controlled over wide ranges for vibration research and test of products up to 411 lbs. maximum load. Any of these five Vibration Test Systems using this New Model CALIDYNE 177 Shaker will enable you to:

1. Discover effects of "brute force" shaking on your assemblies and determine their ability to withstand vibrations far beyond those of normal operation.
2. Provide factual vibration data essential in determining mode shape, frequency and damping characteristics.
3. Determine results of fatigue testing at extremely high stresses and deflections.

CALIDYNE VIBRATION TEST SYSTEMS USING NEW MODEL 177 SHAKER

	System Number	Type of Vibration	Force Output	Power Supply	Frequency Range	Maximum Load 10 g.	Maximum Load 20 g.
1	177/80	Sinusoidal	3500 lbs.	Electronic	5-2500 cps.	261 lbs.	86 lbs.
2	177/180	Sinusoidal	5000 lbs.	Rotary	5-2000 cps.	411 lbs.	161 lbs.
3	177/186	Sinusoidal	5000 lbs.	Electronic	5-2500 cps.	411 lbs.	161 lbs.
4	177/190	Random or Sinusoidal†	5000 lbs.	Electronic	5-2500 cps.	411 lbs.	161 lbs.
5	177/190	Random†	5000 lbs.	Electronic	5-2500 cps.	411 lbs.	161 lbs.

† *This system will perform with Random, Sinusoidal, Tape or Mixed Inputs.*

A separate Bulletin 17700 details the specifications, performance data, basic components and accessories of the new Model 177 CALIDYNE Shaker and its five Shaker Systems. For engineering counsel in applying Controlled Vibration to your research and testing, call us here at CALIDYNE — Winchester (Boston) 6-3810.

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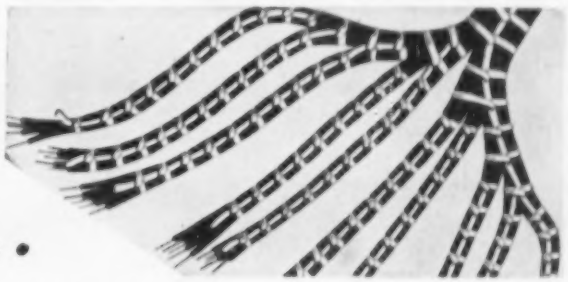

NEW...

TEFLON-GLASS FIBER LACING TAPE

New Ben-Har Braided Lacing and Winding Tape combines two superior insulation materials—DuPont Teflon and glass fibers. Fibers are Teflon coated before braiding to maintain rough texture and assure tight knots—and to eliminate abrasive action of the glass. Ben-Har Tapes will not shrink and cut through insulated wires. They are pliable from −100°F. to 500°F. They are non-absorbent and inert to most known chemicals and oils . . . completely wax-free and fungus proof.

Available in 3/64, 1/16, 3/32 and 1/4 inch widths, in Offwhite. Also available in 8 colors and Black on special order. Write for prices and samples.

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Any aircraft landing gear requirement you have can be solved by Cleveland Pneumatic. The gear can be designed around a conventional AEROL, a new-type high-pressure AEROL, or a Cleveland Pneumatic liquid spring. We engineer and produce all three types of shock absorbers.

If space aboard is extra-tight, the small-cubage Cleveland Pneumatic liquid spring gives you the greatest shock absorption in the smallest package. Static pressures as high as 20,000 psi can be used.

Another weight- and space-saver is the high-pressure AEROL. It was developed by Cleveland Pneumatic to operate at 5,000 psi static pressure with special CPT pressure seals. (Tests were successful up to 8,000 psi static.)

Tell us your landing gear requirements at the start. Cleveland Pneumatic designs and builds all types of landing gear, recommends the type best for your service needs.

Write for the 8-page technical booklet which describes the principle of the liquid spring. Ask for "Booklet LS-10".

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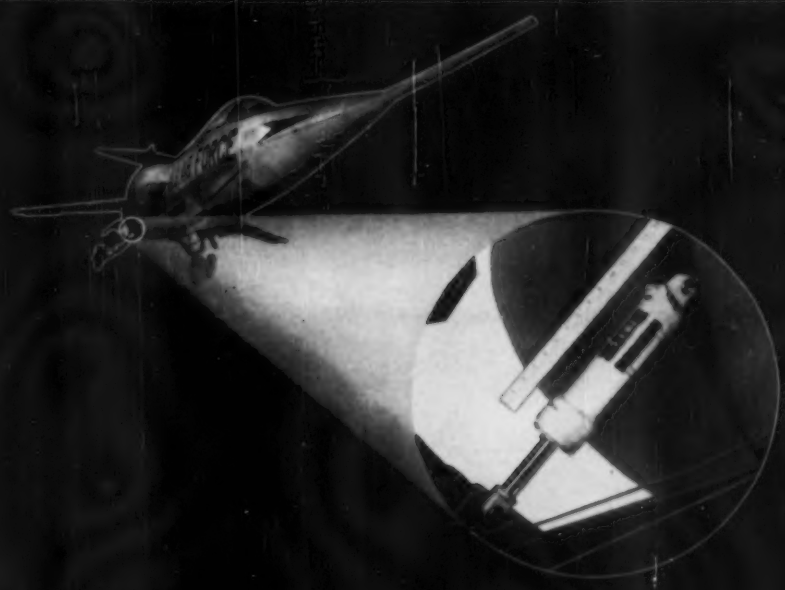
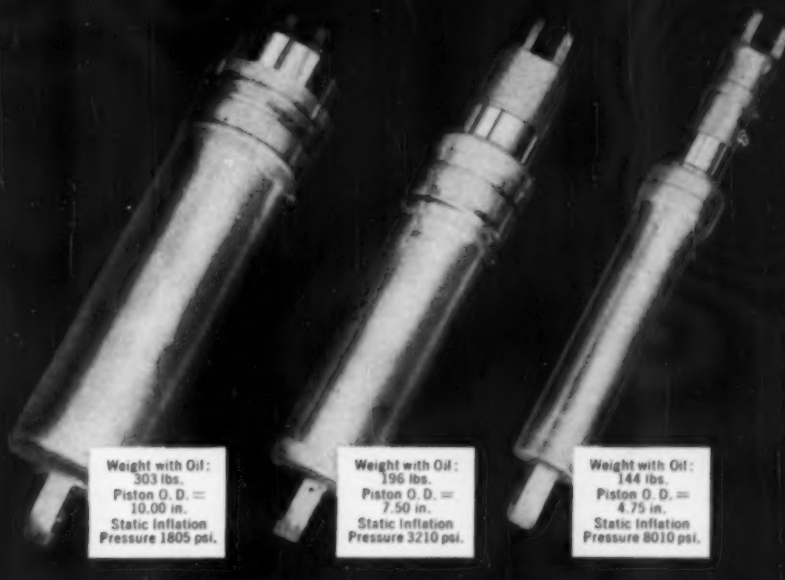


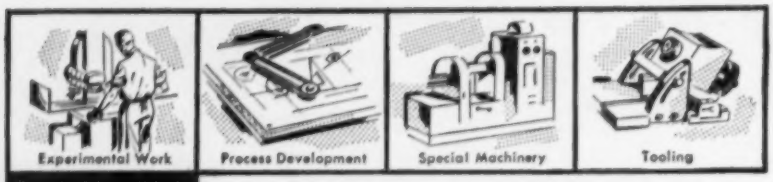
LIQUID SPRING ON LOCKHEED F-104 PROVIDES MAXIMUM IMPACT ABSORPTION IN LEAST SPACE

High-pressure seals developed by Cleveland Pneumatic provide leak-proof operation at static pressures up to 20,000 psi.

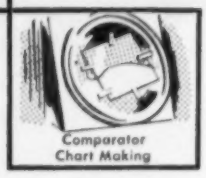

Weight with Oil: 303 lbs.
Piston O. D. = 10.00 in.
Static Inflation Pressure 1805 psi.
Weight with Oil: 196 lbs.
Piston O. D. = 7.50 in.
Static Inflation Pressure 3210 psi.
Weight with Oil: 144 lbs.
Piston O. D. = 4.75 in.
Static Inflation Pressure 8010 psi.

THREE PRESSURE-RANGES OF AEROLS SHOW BENEFITS OF HIGH PRESSURE

Comparison of (left) standard low-pressure AEROL, (middle) medium-pressure AEROL and (right) high-pressure AEROL. Note reduction in diameter of shock-absorber package.



which of these WINSLOW services do you need?



Winslow Standard Guillotine Gage

Winslow Standard Multi-Jet Gage

Winslow Standard Length Gage

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For any precision metalworking plant, Winslow offers a complete consulting engineering service that covers everything but actual design of the product and its actual manufacture. This service is based on years of working in close co-operation with *all* of the country's aircraft engine manufacturers and on Winslow's large investment in metalworking research.

Starting with your part print, Winslow works out process problems, determining how the part can be efficiently manufactured. Equipment is specified and floor-planned. Special machinery needed is designed and built by Winslow, as well as special tools and gages. Efficiency and accuracy control procedures are set up.

Winslow's large staff of engineering designers and metalworking experts represents long experience with a great variety of different problems. Winslow has completely set up a number of plants for important manufacturers. All of Winslow's consulting service—or any part of it—is available to you.

WRITE FOR ENGINEERING BROCHURE

Winslow's "Engineering Brochure" describes in detail the Winslow consulting service, tells how Winslow works with customers. Included are actual case histories of typical Winslow jobs and the Winslow customer list.

Winslow's Guillotine, Multi-Jet and Length Gages are the standard of the jet engine industry for blade contour, thickness and length control. Like other Winslow gages, they feature Winslow's unique "interchangeable parts" design to cut costs, avoid obsolescence, give "More Accuracy for Less Money." Write for literature.

York 16, N.Y. $10.00; 227 pp.

This book describes the history, special problems, and current methods of research and experiment related to high-speed and supersonic flight.

Viscous Flow Theory II: Turbulent Flow—by Shih-I Pai—Pub. by D. Van Nostrand Co., Inc., 120 Alexander Street, Princeton, N. J. $6.75; 277 pp.

The second in a two volume work on viscous flow theory, this book presents for the first time a detailed systematic treatment of the fluid dynamics of turbulent flow.

Energy—by Sir Oliver Lodge—Pub. by John F. Rider Publisher, Inc., 116 West 14th Street, New York 11, N. Y. $1.25; 64 pp.

This is a modernized reprint of the original work dealing with the forms of energy and making clear fundamental concepts.

Antennas—by Alexander Schure—Pub. by John F. Rider Publisher, Inc., 116 West 14th Street, New York 11, N. Y. $1.50; 88 pp.

Volume 14 in the Electronic Technology Series by Dr. Schure, it covers both theory and practical application; transmission lines, the basic antenna input impedance, polarization, etc., from the basic dipole, through parasitic arrays, long wire and other antennas.

Wave Propagation—by Alexander Schure—Pub. by John F. Rider Publisher, Inc., 116 West 14th Street, New York 11, N. Y. $1.25; 64 pp.

This book deals with the fundamental nature of electromagnetic radiation covering the various factors involved in the makeup and transmission of electromagnetic waves, with emphasis on the propagation of these waves.

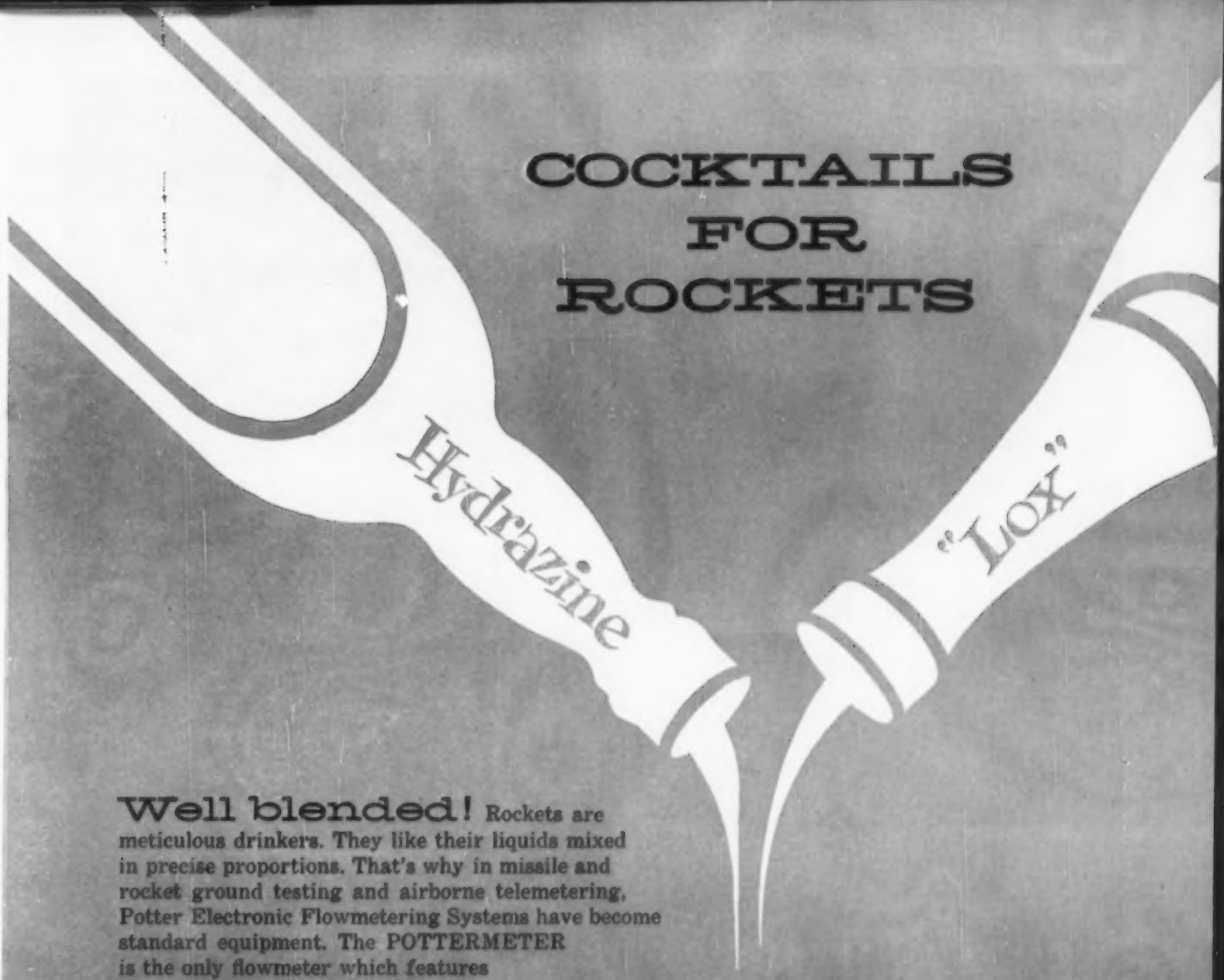
The Conquest of the Antarctic—by Norman Kemp—Pub. by Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. $4.75; 152 pp.

An interim report bringing together all available information on four separate expeditions, British, New Zealand, American, Russian, which are, this year, exploring Antarctica.

ASTM Standards on Petroleum Products and Lubricants—Available from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa. $7.50, cloth-covered edition; $6.75 paper-covered; 1096 pp.

Includes tentative and standard methods of test, specifications, definitions of terms and classifications of petroleum products and lubricants with related information. The present edition includes 180 standards, 48 of which are new or revised since the previous edition.

COCKTAILS FOR ROCKETS



Well blended! Rockets are meticulous drinkers. They like their liquids mixed in precise proportions. That's why in missile and rocket ground testing and airborne telemetering, Potter Electronic Flowmetering Systems have become standard equipment. The POTTERMETER is the only flowmeter which features the hydraulically positioned, *bearingless* rotor.

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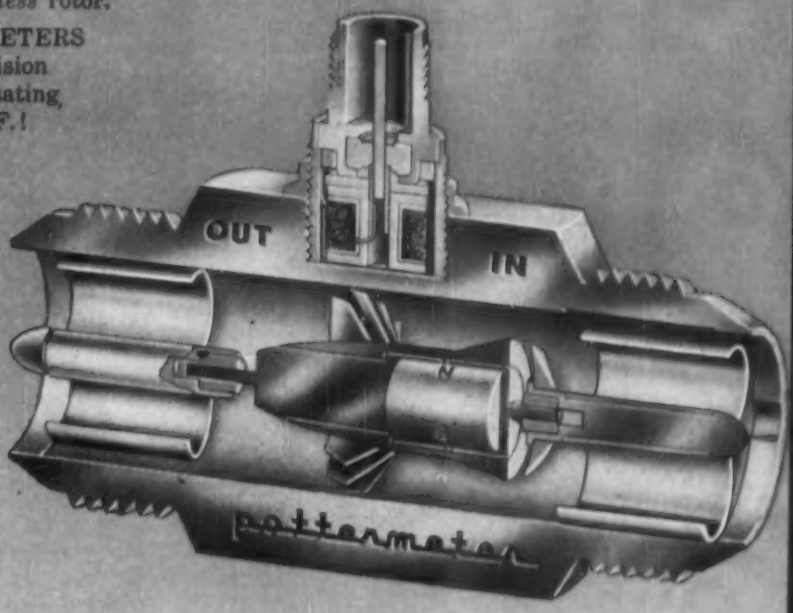

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Instrument transformers, underground service cables, high voltage industrial cables . . . in these, and many other electrical applications, Enjay Butyl out-performs and out-lasts *all other* types of rubber, synthetic *or* natural. *Low-in-cost* and *immediately available*, this truly wonder rubber may well be able to cut costs and improve performance in *your* products. For further information, and for expert technical assistance, contact the Enjay Company.

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Solid State Advances, Trends Detailed

By Philip J. Klass

New York—Solid-state components which promise to revolutionize avionics circuit design as much or more in the next decade as the transistor has done in the past decade were described here during the recent symposium on The Role of Solid State Phenomena in Electric Circuits.

More than 900 scientists and engineers, including representatives from half a dozen foreign countries, heard Dr. Paul P. Ewald call solid state physics "a field of great depth whose surface we have only started to penetrate."

Ewald is head of the Physics Department at Polytechnic Institute of Brooklyn, whose Microwave Research Institute sponsored the symposium in association with the Air Force Office of Scientific Research, the Office of Naval Research, the Signal Corps Engineering Laboratories and the Institute of Radio Engineers.

Military Interest

One indication of the military importance of solid state physics is the fact that the commanding officers or chief technical scientist of all three sponsoring military agencies were present to address the symposium.

Brig. Gen. Earl F. Cook, Signal Corps Engineering Laboratories chief, called solid state physics "a veritable gold nugget" in its potentialities for military cases.

Brig. Gen. H. F. Gregory, chief of the USAF's Office of Scientific Research, and Dr. Thomas J. Killian, chief scientist of the Office of Naval Research, both hailed the newly developed Maser (solid-state microwave amplifier) as a potential breakthrough in the radar and communication fields. Both said their branches seek to accelerate Maser development and application.

Revolution In Components

Potentiometer that uses no sliding contacts, a relay that has no moving parts, a variable capacitor that can be electrically tuned, and gyrator that operates at low frequencies in apparent violation of basic laws of electricity—these are some of the semiconductor components coming out of solid state physics research which are described in Aviation Week's report on the recent symposium on Solid State Phenomena in Electric Circuits.

Dr. M. W. P. Strandberg of the Massachusetts Institute of Technology and Dr. J. C. Artman of Harvard reported on their Maser investigations. MIT is investigating a two-level Maser, while Harvard is researching a three-level device.

Here are some of the new solid-state components and techniques reported by symposium speakers:

• **Cryotron amplifier.** This recent development, which makes use of the fact that certain materials have practically zero resistance (superconductivity) at extremely low temperatures which can be sharply increased by the application of a magnetic field, previously has been used only as an on-off switching device in computers. Both Dr. H. O. McMahon of Arthur D. Little, Inc. and E. W. Herold of Radio Corporation of America reported that the cryotron can be used as a triode amplifier. Herold also suggested that superconductive materials could be used to achieve extremely low-loss microwave circuits.

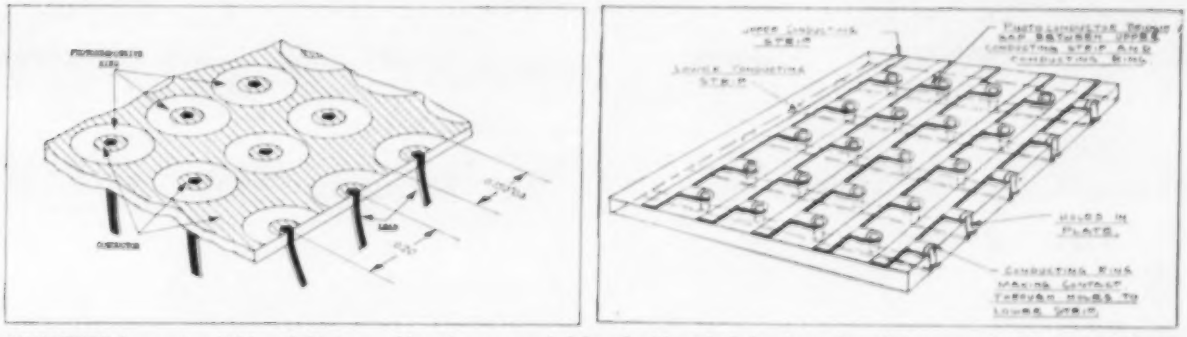
• **Semiconductor variable capacitor.** That the capacitance of a P-N junction can be changed by a factor of 3:1 by varying its back voltage suggests that modified versions of present diodes can be used as voltage-tunable variable capacitors and for capacitive amplifiers, Herold suggested.

• **Low-frequency Hall gyrator.** The Hall-effect ferrite gyrator, a solid-state device now used at microwave frequencies to isolate a radar transmitter from unwanted reflections, is not limited to microwave frequencies and opens up interesting low-frequency circuit possibilities, Herold said.

• **Magnetic potentiometer.** Indium antimonide, a promising and versatile new semiconductor material whose conductivity changes sharply when subjected to a magnetic field, can be used as a static potentiometer whose resistance is varied electrically by changing the applied magnetic field. Another application of the same principle, also suggested by Dr. T. S. Moss of the British Royal Aircraft Establishment, is a relay with no moving parts which can be switched from on to off with the application of a magnetic field.

• **Electronic commutator.** Multi-element transistor which provides commutation between one input and several output circuits, or vice versa, with no moving parts was described by Dr. G. C. Sziklai of Westinghouse Electric Corp. (L. R. Hill was co-author of the paper.) Switching times as short as ½ microsecond and power handling capacity of up to 50 watts appear feasible, with isolation of 20 db. or better between adjacent circuits, Dr. Sziklai indicated.

• **Luminescence-effect amplifier.** Semiconductor amplifier which accepts an a.c. input signal, converts it to luminescence which in turn controls the amplified d.c. output was described by Dr. R. E. Halsted of General Electric's



MINIATURE low-cost switching (left) is possible using copperclad board with etched doughnut-shape holes covered with photoconductor material which conducts when illuminated by electron beam. Matrix for computer switching (right) employs similar principle.

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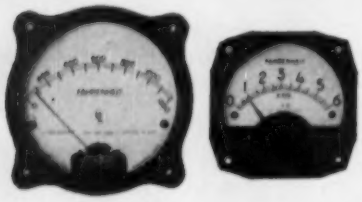
Indicating Pyrometers

for temperature testing in the laboratory or in the plane...

Constructed with the same care as our aircraft temperature indicators, these pyrometers bring "aircraft quality" to the test engineer.

MODEL 58PY, above, has been used extensively by leading motor car manufacturers for road testing on the "Proving Grounds" — where performance counts. Housed in rectangular bakelite case, has 6" hand drawn scale and is fully compensated for ambient temperature. Made in ranges listed below, with suitable thermocouple materials.



MODEL 23B, left above, has same type movement as our aircraft pyrometers. Housed in flanged, 4" round, bakelite case for panel mounting.

MODEL 20B, right above, has same 3" steel case and same movement as our aircraft panel indicators. Both are fully cold-end compensated and available in standard ranges listed, with suitable thermocouple materials.

STANDARD RANGES—All Models
FAHRENHEIT
Zero to 400, 600, 800, 1000, 1200, 1600, 1800, 2000 and 2500.
CENTIGRADE
Zero to 200, 300, 400, 500, 600, 800, 1000, 1100 and 1400.

Furnished with white scales, black markings and pointer or, with black scales white markings and pointer if specified. For best results use LEWIS Thermocouples, Leads and Selector Switches with these instruments.

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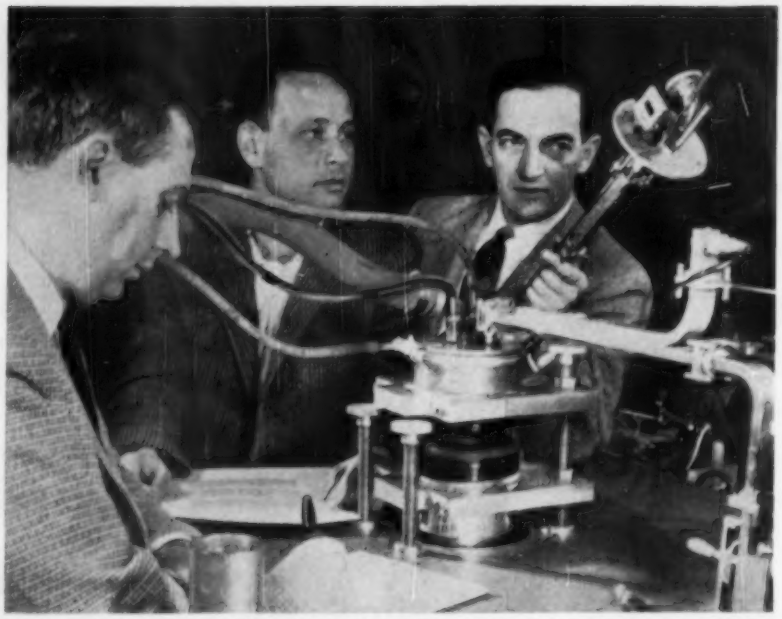


SOLID-STATE MASER, a microwave amplifier with very low noise characteristics, appears to offer major gains in radar and communications. Military interest in Maser is high.

Research Laboratory. GE has constructed luminescence amplifiers with power gains of 70,000, Dr. Halsted reported. Advantages of the device include high input impedance and electrical isolation between input, output.

• **Microwave/infrared modulator.** Modulation of radar energy by inserting a thin slab of germanium in a waveguide and applying a control current or high-voltage field to it was reported by Dr. J. W. Granville of the British Radar Research Establishment. (A. F. Gibson was co-author.) One such modulator tested could handle radar pulse repetition rates up to 100 per second and pulse widths of one microsecond. However theory suggests that the device should be able to operate at rates up to 10^{-12} per second, Granville indicated. Similar techniques have been tried in the infrared spectrum with only limited success using germanium but Granville believes that the use of silicon will overcome these limitations.

Photoconductive Switching

Use of photoconductive techniques to provide a relatively low-cost, moderately high-speed switching matrix was suggested by Jenny E. Rosenthal (Mrs. A. Bramley) in a paper co-authored by her husband. Both are employed at the Allen B. DuMont Laboratories.

The switching potentialities of photoconductors arises from the fact that their dark resistance of about 100 megohms drops sharply when illuminated—to about 1,000 to 100,000 ohms, depending upon the material and intensity of illumination.

One configuration suggested by the Bramleys consists of a series of small doughnut-shaped areas (0.15 in. outer diameter) etched on a copper-clad phenolic board. Incoming leads are attached to each of the copper islands (doughnut holes). The doughnut shaped areas separating these islands from the common copper conducting surface are then coated with a photoconductive material.

Switching Leads

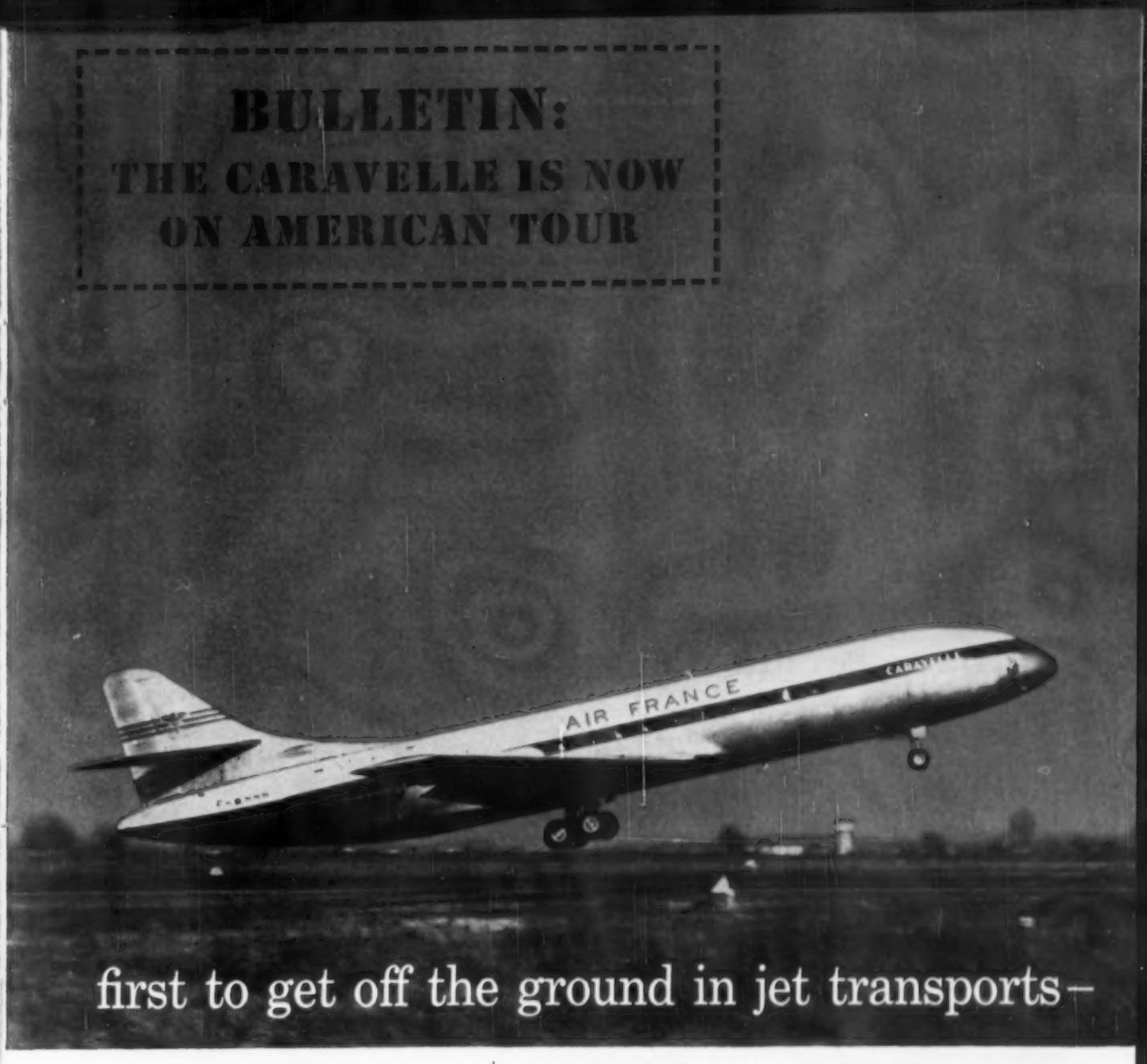
To switch any one of the incoming leads to the common conductor, it is only necessary to focus a small spot of light on the photoconductive area, causing its resistance to drop sharply and permit current flow. To provide a light source for high-speed switching, the board with the photoconductive doughnuts is placed up against the face of a cathode ray tube. By positioning the CRT electron beam, it is possible to illuminate any photoconductive switch which is to be activated.

To provide a full switching matrix for computer logical circuits, a set of parallel conductors is etched on one side of the copper-clad board, and another set is etched at right angles on the opposite side. Each of the conductors on one side is connected to a row of photoconductive doughnuts. The inner copper islands of each of these doughnuts in turn is connected to one of the underneath conductors running at right angles to those on top.

To connect any one of the top conductors to any one of the bottom conductors, it is only necessary to select and illuminate the proper one.

Mrs. Bramley reported that the

BULLETIN:
THE CARAVELLE IS NOW ON AMERICAN TOUR



first to get off the ground in jet transports–

LEAR TRANSISTORIZED AUTOPILOTS

AT THE VERY DAWN of the jet transport age, Lear automatic flight controls are already in the air guiding Air France's Caravelle jet transports on route indoctrination and demonstration runs. And when the Caravelle enters regularly scheduled passenger service next year, the first all-transistorized airliner autopilot, a Lear L-17, will be at the controls, providing standards of safety, accuracy and comfort beyond a human pilot's ability.

Manufactured by Sud Aviation of France, the Caravelle is scheduled to visit the following cities: WASHINGTON, D. C., May 8-13; ATLANTA, May 13-15; MIAMI, May 15-20; DALLAS, FT. WORTH and HOUSTON, May 21-23; KANSAS CITY, May 23-26; ST. LOUIS, May 26-27; CHICAGO, May 28-June 3; DENVER, June 3-5; SALT LAKE CITY, June 5; LOS ANGELES, June 5-10; SAN FRANCISCO, June 10-13; SEATTLE, June 13-17; CHICAGO, June 17-19; NEW YORK CITY, June 19-20; MONTREAL, June 20-23.

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EXTREME COLD in Arctic operations has little effect on the compact, reliable Mars auxiliary power unit used on the Boeing KC-97 tanker. Often running continuously day in and day out, the dependable Mars-powered generator set keeps the cabin comfortable at below-zero temperatures. It supplies electric power also for engine preheating and starting systems as well as for other auxiliary equipment.

Solar's 50 hp Mars gas turbine is the heart of the airborne power unit. The Mars engine weighs less than 100 pounds, is smaller than a two-foot cube. It starts easily from 130F to –65F ambient temperatures, operates on a variety of fuels, is simple to maintain, and requires infrequent overhauls. In addition to the KC-97, Mars auxiliary power units are employed on the Douglas C-124C, the Lockheed C-121C and Convair C-131B.

Perhaps the Mars gas turbine can help solve your need for a light, compact, powerful engine. Write to Dept. D-23, Solar Aircraft Company, San Diego 12, California, for more data on the Mars gas turbine.

WRITE FOR BOOKLET

New brochure describes Solar gas turbines—how they work, advantages they offer. Ask for a copy.

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* Mars is the registered trade mark for Solar's line of 50 hp gas turbine engines.

Research Pays Off

Direct military gains from basic research which seeks knowledge and understanding instead of being directed toward specific military objectives is pointed up by recent developments in solid-state physics.

Five years ago the military services were criticized for supporting extremely low-temperature research because it had no obvious military application. Yet out of this research has come the new Maser microwave amplifier which the military services are now hailing as a potential producer of a technological breakthrough in the radar and communication fields. The Cryotron, another new device which stems directly from low-temperature research, promises a major reduction in the size and cost of digital computers.

End of the pay-off is not in sight.

photoconductive doughnuts can be spaced with their centers approximately 0.2 in. apart, making it possible to produce 25 such switches per square inch. This should make it possible to produce a matrix of 1,000 switches in an area of roughly 40 square inches, or a 10,000 switch matrix on a board measuring only 20 x 20 in.

The technique appears to have the advantages of relatively low cost and simplicity of manufacture. Another advantage for certain applications is the ability of the photoconductive switches to operate at high potentials, 500 to 1,000 volts.

Maximum switching speed of the device depends upon the amount of output current required. If an output current of a few milliamperes is sufficient, switching speeds up to 50 microseconds are possible, Mrs. Bramley reported. Higher currents will require longer switching times.

Indium Antimonide

As a semiconductor material for transistors, indium antimonide has so far proved to be a complete dud. Yet the material has remarkable properties, stemming in part from its very low energy gap, which promise a host of interesting new semiconductor devices.

Indium antimonide shows extremely high magneto-resistance effects. For example, when subjected to a 10,000 gauss field, it experiences an 1,800% change in resistance, compared to the 6% change that occurs in germanium, Dr. T. S. Moss reported. This prompted him to suggest that the new material could be used as a magnetically controlled potentiometer without sliding contacts and as a relay without moving parts.

Indium antimonide could also be used in microphones to provide an extremely high output signal, sufficient for a self-powered intercommunication system without further amplification.

A new type power rectifier, which Moss calls "magnetic barrier layer" is another interesting possibility. It would consist merely of a slab of uniform indium antimonide with ohmic (not junction) contacts, operating in a magnetic field. Back-to-front resistance ratios of 10,000:1 should be possible, Moss predicts.

"A whole family of new devices stem from the use of the Hall effect where indium antimonide has a power efficiency 300 times greater than germanium," Moss said. Here are some of the applications suggested by Dr. Moss:

- **Sensitive compass,** capable of providing an output signal sufficient to drive a remote indicator.
- **Highly sensitive magnetometer,** responsive to as little as 10^{-4} gauss.
- **Low-frequency resistance gyrator,** when used with bridging resistors in a non-reciprocal network, can provide very low forward transmission losses.
- **Motor torque sensor.** Placing a small piece of indium antimonide in an electric motor armature so it is subjected to the same field and connecting it to the armature winding results in a Hall-effect voltage which is proportional to the motor's instantaneous torque. This voltage can be used for indicating or control purposes.
- **Analog computer** multiplying element.
- **Direct-reading** a.c. wattmeter.
- **Modulator.**
- **Hall-effect** galvanometer amplifier, capable of power gains of 5:1.

One of the most important uses of indium antimonide is for infrared detectors, Moss said. The reason is that the upper wavelength limit of sensitivity can be easily controlled by changing its impurity content. At room temperature, indium antimonide has an equivalent noise input (ENI) power of 10^{-9} with peak response at about 6 microns, Moss said. At low temperatures the peak can be extended out to about 7-8 microns, he added.

Knowledge, Not Devices

Despite the foregoing list of impressive new semiconductor devices, primary symposium emphasis was placed on reporting new knowledge and techniques rather than new devices.

For example, Dr. H. Kroemer of RCA Laboratories reported on techniques for creating the equivalent of built-in electric and/or magnetic fields within a semi-conductor material in a controlled manner. He calls these "quasi-electric" and "quasi-magnetic" fields. Dr. Kroemer's current studies are an extension of the discovery which led to the recent "drift transistor," which

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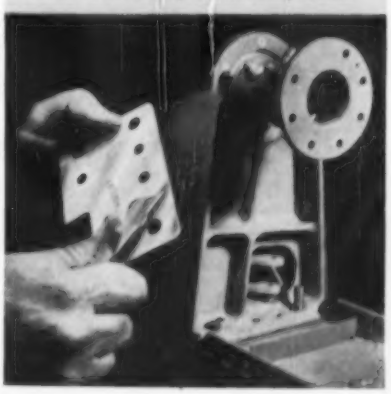

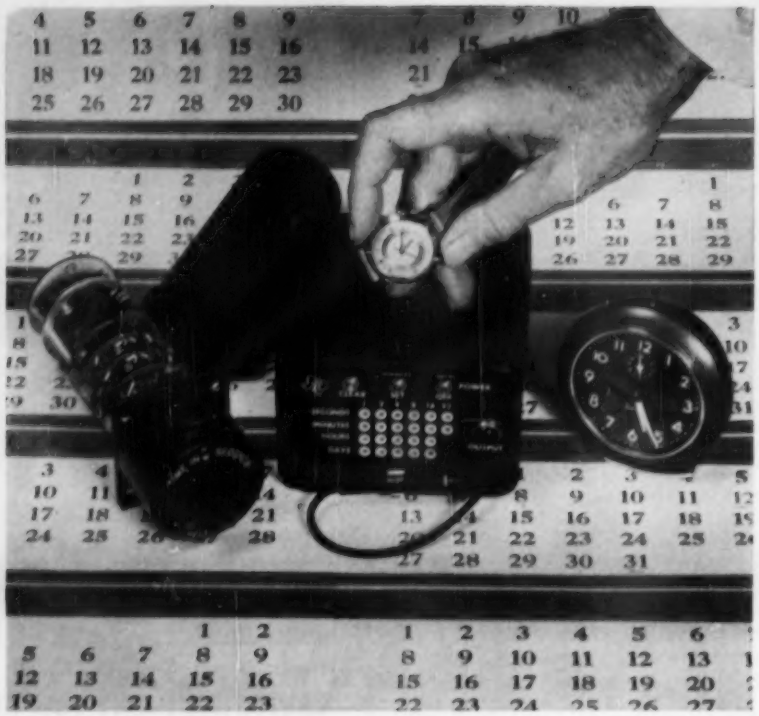

Texas Instruments transistorized timing devices offer new highs in timing / reliability / application

- No moving operational parts
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Already in production, TI transistorized timers are blazing new trails in applications and in performance . . . with extraordinary accuracies and with interval variations to infinity . . . improvements never before practical because of size, weight, power drain, and maintenance limitations.

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3-D Radar Tracker

Track-while-scan system, capable of automatically tracking up to 72 targets in three dimensions, is a hybrid digital-analog device. Error sensing is performed in analog fashion while device is controlled digitally by a digital computer which controls and displays information on all 72 aircraft tracks. Developed by Westinghouse Electric Corporation's Electronic Division in Baltimore, new device employs 1,500 transistors and 11,000 diodes. System has been under test for 10 months.

can operate at very high frequencies.

The quasi-electric and magnetic fields are created by a non-homogeneous distribution of impurity within the semiconductor and by setting up non-uniform elastic strains. This makes it possible to counteract partially the effect of transistor emitter capacitance, thereby increasing the unit's high-frequency response.

The technique produces effects which in some cases would otherwise require the circuit designer to use external circuitry; in other cases it produces internal effects which no external circuitry could duplicate, Dr. Kroemer reported.

One possible application suggested by the quasi-magnetic fields is a solid-state magnetron, but Dr. Kroemer indicated that this is not an immediate prospect.

New Materials

Until recently, designers of semiconductor devices used homogeneous materials, such as silicon or germanium. Basic research in solid-state physics has now opened up a tremendous number of new materials, many of them compounds. A few of the more promising, according to RCA's Herold, include gallium arsenide, indium antimonide and aluminum phosphide.

Another new material, silicon carbide, shows considerable promise for extremely high temperature applications, according to Dr. F. E. Williams

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TRENT TUBE COMPANY, GENERAL SALES OFFICES, EAST TROY, WISCONSIN (Subsidiary of Crucible Steel Company of America)

of General Electric's Research Laboratory. General Electric has just announced that it has operated a silicon carbide rectifier at temperatures up to 1,200F and as low as −100F.

Dr. Guy Suits, vice president and director of GE's research, says: "Although currents of several amperes have been rectified with usable efficiency, the practical future of silicon carbide in rectifiers and other solid-state devices will depend on progress in the preparation of this highly stable but extremely stubborn material."

Future Gains

Symposium speakers in general displayed the customary reluctance of scientists to make predictions beyond the present limits of knowledge.

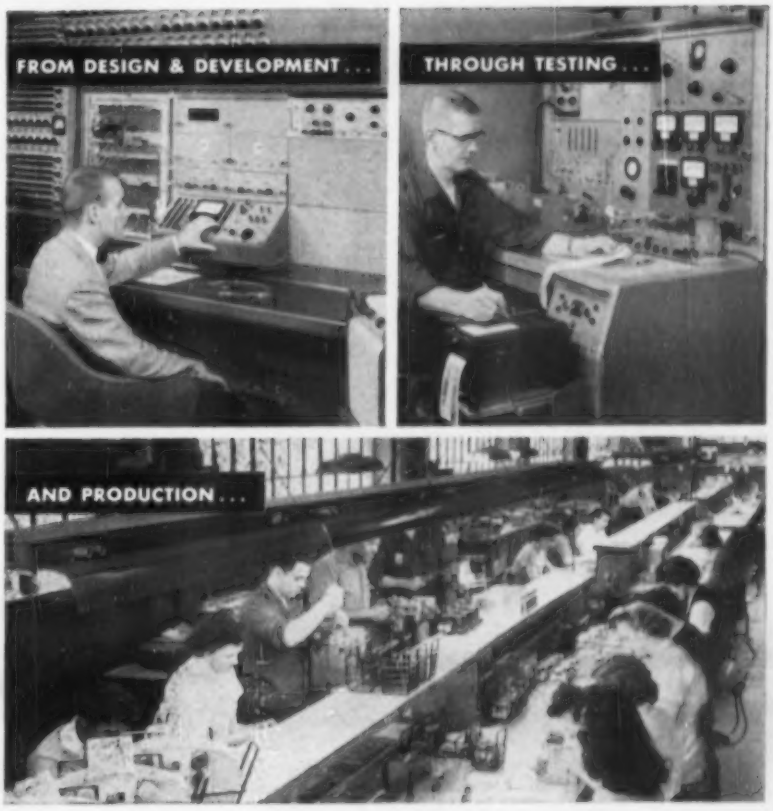
In a symposium round-table discussion, the concensus was that any further gains in the upper frequency limit of transistors probably would be accomplished by improved techniques for controlling the internal geometry of the transistor rather than from any new materials. However, the group agreed that the possibility of some new compound capable of providing higher frequency operation could not be ruled out.

RCA's Herold predicted that it should be possible to fabricate complex solid-state circuits capable of performing several functions. This substantiates similar views of other scientists recently reported by Aviation Week (April 8, p. 86).

FILTER CENTER

► **Maser Development**—Hycon-Eastern is developing a two-state Maser (solid-state microwave amplifier) for Rome Air Development Center to enable it to evaluate new device's potentialities in radar and scatter communication systems. The two-state type Maser, under investigation at Massachusetts Institute of Technology, may be limited to pulse-type operation. Three-state Maser under investigation at Harvard can reportedly be used for both pulse and CW type service, but has other limitations. Other groups active in Maser development include: Columbia University, Bell Telephone Laboratories, General Electric, Hughes Aircraft Co., Radio Corporation of America, and Westinghouse Electric.

► **Electronic Refrigerator**—Battelle Institute is investigating bismuth telluride and other tellurium-base semiconductor compounds for possible application to electronic refrigeration, rectifiers and solar batteries. Battelle scientists say that bismuth telluride has theoretical capacity to cool and liquefy air directly



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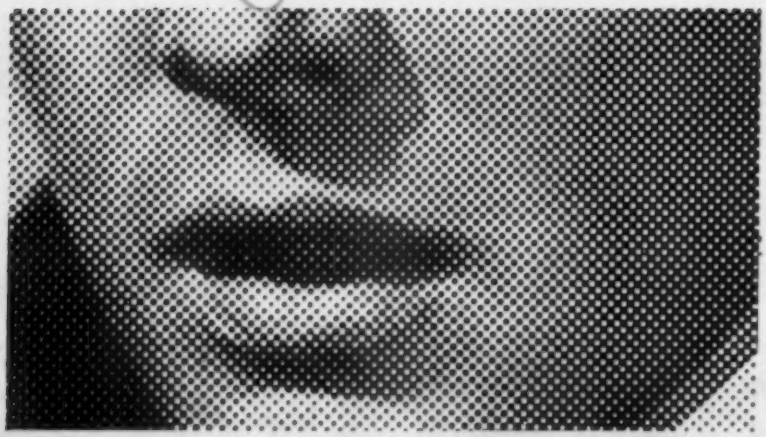

communication is a sometime thing

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without resorting to compression, using Peltier effect. (For explanation of Peltier cooling, see AVIATION WEEK, May 23, 1955, p. 33.)

► **M-H Inertial Guidance**—Minneapolis-Honeywell reports it is flight testing an inertial guidance system called ISIP, short for Inertial System, Indicating Position. Flights have ranged over several hundred mile courses, M-H says.

► **Small Drops Important**—Thin invisible film of air between a transistor or other component and equipment chassis can reduce heat conduction from the device to the chassis. Solution recommended by at least one transistor manufacturer is to place drop of silicone oil between component and chassis.

► **Some Sunspots Are Good**—Contrary to popular belief, some sunspots actually improve radio transmissions, Radio Corporation of America reports based on recently completed 10-year study of solar radio disturbances. RCA's study indicates that sunspots which are rich in ultraviolet light have a favorable effect because they strengthen the ionosphere. John Nelson of RCA Communications, Inc., who made the study, has developed theory that sunspots are the result of collective action of the gravitational fields of solar system planets circling the sun. On the basis of his theory, Nelson has been able to predict major sunspot activity with an accuracy of better than 90%, RCA reports.

► **Man-Made Electron Cloud Tests**—Tests to determine the degree to which radio signals will bounce off man-made ionized clouds created by releasing nitric oxide from a rocket in the upper atmosphere, will begin early in July. Tests, sponsored by Air Force Cambridge Research Center, will be conducted at Holloman Air Development Center, and will enlist the aid of scores of amateur ("ham") radio operators in the southwest.

► **Data Conversion Course**—Massachusetts Institute of Technology will hold five-day course in analog-digital conversion techniques, starting Aug. 12. Program will be under direction of Alfred K. Susskind of MIT's Electrical Engineering Dept. in cooperation with the Servomechanism Laboratory. Tuition is $175.

► **Electronic Communications, Inc.** is new name of Air Associates, changed by vote of stockholders to reflect more accurately future aims of company. Air Associates name will be retained as a division. Gradual relocation under way will place all manufacturing and engineering operations at St. Petersburg, Fla., and new research laboratory is under construction at Timonium, Md.

► **Dectra Tests Soon**—North Atlantic evaluation tests on Dectra long-range navigation system are slated to begin soon. Dectra is the British competitor to the U. S. Navaho system for adoption by International Civil Aviation Organization. Two Dectra stations in Newfoundland are in operation and two English stations will soon go on the air, Decca Navigation Co. reports. Major North Atlantic carriers will participate in system evaluation, Decca says.

► **New Business**—Following avionics companies have recently announced receipt of major new contracts:

• **Federal Telephone & Radio Co.**, Clifton, N. J., has received $2.2 million contract from Air Materiel Command for "reader computers." Details of the equipment and its use are classified, FTR says.

• **Farnsworth Electronics Co.**, Ft. Wayne, Ind., has received additional orders amounting to approximately $12 million from Boeing Airplane Co. for ground support and test equipment to be used with the Bomarc ground-to-air missile.

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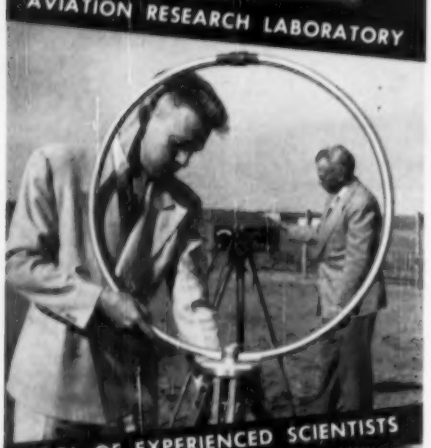
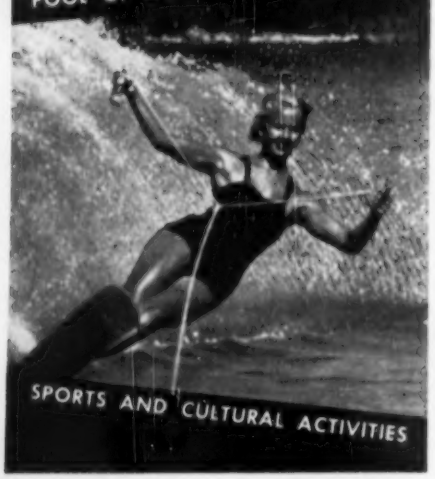


POOL OF EXPERIENCED SCIENTISTS



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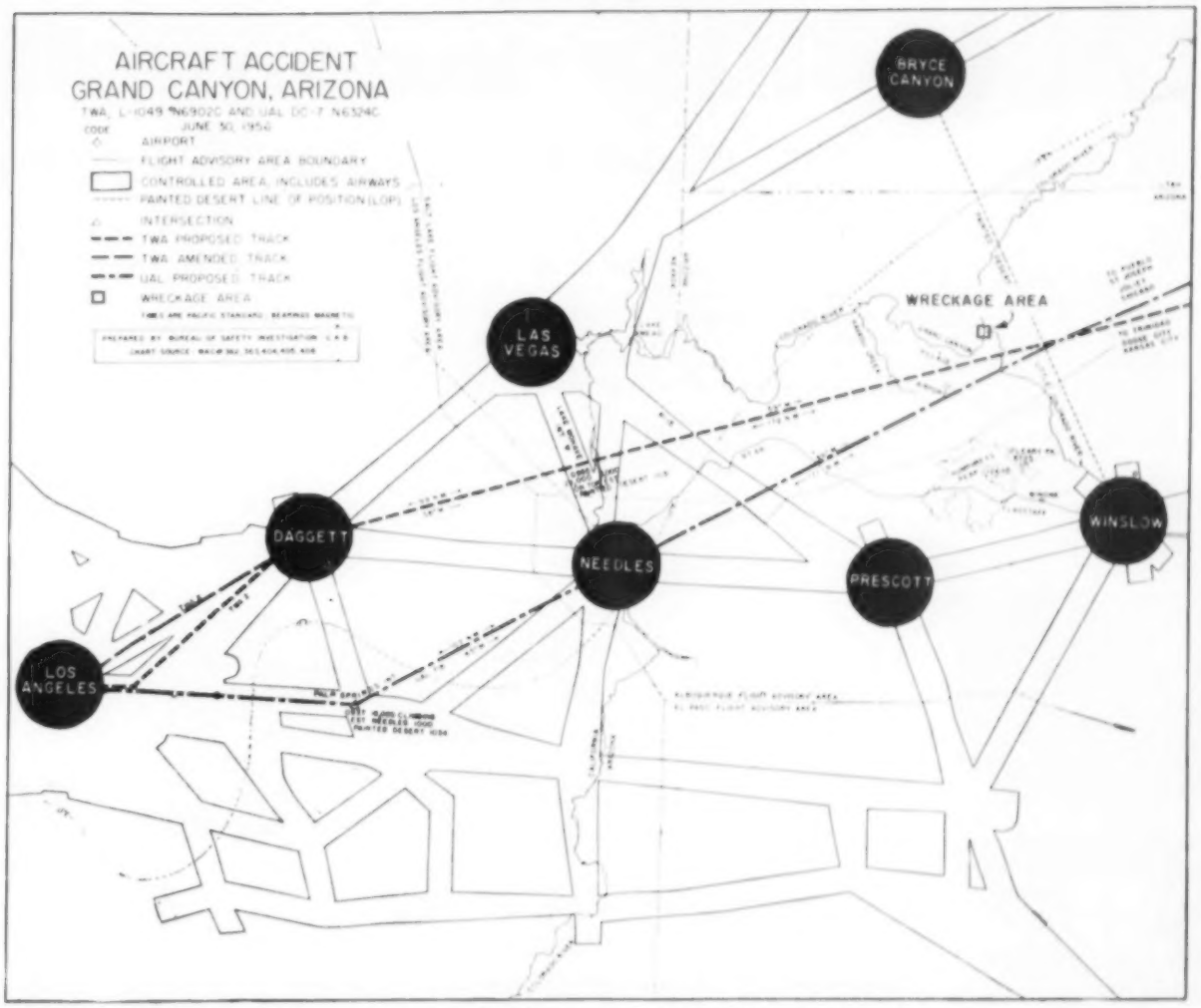

COURSES of TWA, United airliners through controlled air space met at Painted Desert position line.

CAB Accident Investigation Report

Visual Failure Blamed in Canyon Crash

At approximately 1031,[1] June 30, 1956, a Trans World Airlines Lockheed 1049A, N 6902C, and a United Air Lines Douglas DC-7, N 6324C, collided at about 21,000 ft.[2] over Grand Canyon, Ariz. Both aircraft fell into the Canyon near the confluence of the Colorado and Little Colorado Rivers. There were no survivors among the 128 persons aboard the flights, 70 aboard TWA and 58 aboard United. Both aircraft were destroyed.

• Trans World Airlines.

On June 30, 1956, at 0901, Trans World Airlines Flight 2, a regularly scheduled passenger service, took off from runway 25 of the Los Angeles International Airport. Flight 2 was on an instrument flight rules (IFR) flight plan from Los Angeles, Calif., to Kansas City, Mo., via Green Airway 5, Amber Airway 2, Daggett direct Trinidad, direct Dodge City, Victor Airway 10 Kansas City.

The flight plan also proposed a cruising altitude of 19,000 ft., a true airspeed of 270 kt., and a departure time of 0830. The Trans World flight crew consisted of Capt. Jack S. Gandy, Copilot James H. Ritner, Flight Engineer Forrest D. Breyfogle, Flight Engineer Harry H. Allen (aboard as an additional crew member), and Hostesses Trancine E. Armbruster and Beth E. Davis.

Preparations for Flight 2 were routine except that departure was delayed a few minutes by minor maintenance on the aircraft. The flight was dispatched with 3,300 gal. of fuel and the load manifest showed the gross weight of the aircraft at takeoff was 108,115 lb., well under the maximum allowable of 113,200 lb. The load was properly distributed with respect to center of gravity limitations of the aircraft.

As requested, the flight, after takeoff, contacted the Los Angeles tower radar departure controller, and was vectored through an overcast which existed in the Los Angeles area. After reporting "on top" (2,400 ft.) the flight switched to Los Angeles Air Route Traffic Control Center (referred to as Los Angeles Center) frequency, 118.9 mcs., for its en route clearance. This clearance specified the routing as filed in the flight plan. However, the controller specified that the flight climb to 19,000 ft. in VFR conditions. Immediately thereafter

[1] Times herein are Pacific standard and based on the 24-hour clock.

[2] Altitudes herein are mean sea level, distances are nautical miles unless otherwise indicated.

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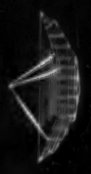
Collins engineers, designs and supplies the equipment, installs, and puts into operation integrated point-to-point communication systems of any scope. The Collins system engineering staff is backed by the finest equipment in the world, whether standard MF, HF or VHF, Transhorizon "scatter," microwave relay and multiplex or single sideband HF. Typical of Collins communication progress is "Kineplex" — a high speed data transmission system doubling communication capacity.



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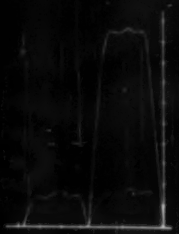

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High-strength castings can be made in sand or plaster molds . . . sometimes in permanent molds. Alcoa's standard guarantee of properties for alloy A356-T61 is 38,000 psi tensile, 28,000 psi yield, and 5% elongation. Occasionally, because of complex shapes and designs, high strength can be furnished only in certain areas of the casting. But, by working closely with the designer, Alcoa can usually put the high strength right where it's needed.

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Important missile structural castings for Douglas. Alcoa's high-strength casting process and alloy A356-T61 give them some of the highest properties ever cast. Here are the properties obtained on test bars cut from the castings.

	Tensile, ksi	*Yield, ksi*	*Elongation, %*
Front Casting			
Average	43.2	32.1	9.7
Maximum	44.4	34.1	11.0
Minimum	40.5	30.3	6.7
Tests—8 from 8 production runs			
Back Casting			
Average	45.1	34.3	5.5
Maximum	47.1	36.9	9.0
Minimum	40.2	32.2	4.0
Tests—22 from 12 production runs			
Minimum Required	**40.0**	**30.0**	**3.0**

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TWA 2 asked for a routing change to Daggett via Victor Airway 210. This was approved in a routine manner.

At 0921, through company radio communications, Flight 2 reported that it was approaching Daggett and requested a change in flight plan altitude assignment from 19,000 to 21,000 ft. ARTC (Los Angeles Center) advised it was unable to approve the requested altitude because of traffic (United Air Lines Flight 718). Flight 2 requested a clearance of 1,000 ft. on top. Ascertaining from the radio operator that the flight was then at least 1,000 on top, ARTC cleared the flight.

At 0959 Trans World 2 reported its position through company radio at Las Vegas. It reported that it had passed Lake Mohave at 0955, was 1,000 on top at 21,000 ft., and estimated it would reach the 321 deg. radial of the Winslow omni range station (Painted Desert) at 1031 with Farmington next. This was the last radio communication with the flight.

• United Air Lines

United Air Lines Flight 718 was regularly scheduled from Los Angeles to Chicago, Ill. On June 30, 1956, it took off from runway 25L (left) of the Los Angeles International Airport at 0904 (three minutes after TWA 2). Flight 718 was on an IFR flight plan to Chicago via Green Airway 5 Palm Springs intersection, direct Needles, direct Painted Desert, direct Durango, direct Pueblo, direct St. Joseph, Victor Airway 116 Joliet, Victor Airway 84 Chicago Midway Airport.

Flight Plan

Flight plan proposed a true airspeed of 288 kt., a cruising altitude of 21,000 ft., and a departure time of 0845. The flight crew consisted of Capt. Robert F. Shirley, First Officer Robert W. Harms, Flight Engineer Gerard Fiore, and Stewardesses Nancy L. Kemnitz and Margaret A. Shoudt.

Flight preparations and dispatch of United 718 were routine and the aircraft departed with 3,850 gal. of fuel. The company load manifest showed the gross weight of the aircraft at takeoff to be 105,835 lb., which was less than the maximum allowable of 114,060 lb. The latter weight was restricted from a maximum of 122,200 lb. for the aircraft because of a landing limitation at Chicago. The load was properly distributed with respect to the center of gravity limitations of the aircraft.

After takeoff the flight contacted the Los Angeles tower radar controller, who vectored it through the overcast over the same departure course as TWA 2. United 718 reported "on top" and changed to Los Angeles Center frequency for its en route clearance. This corresponded to the flight plan as filed, however, the controller specified that the climb to assigned altitude be VFR.

Flight 718 made position reports to Aeronautical Radio, Inc., which serves under contract as United company radio. It reported passing over Riverside and later over Palm Springs intersection. The latter report indicated that United 718 was still climbing to 21,000 ft. and estimated it would reach Needles at 1000 and the Painted Desert at 1034.

At approximately 0958 United 718 made a position report to the CAA communications station located at Needles. This report stated that the flight was over Needles at 0958, at 21,000 ft., and estimated the Painted Desert at 1031, with Durango next.

At 1031 an unidentified radio transmission was heard by Aeronautical Radio communicators at Salt Lake City and San Francisco. They were not able to understand the message when it was received but it was later determined by playing back the recorded transmission that the message was from United 718. Context was interpreted as: "Salt Lake, United 718 . . . ah . . . we're going in."

INVESTIGATION

When neither flight reported passing the Painted Desert line of position, CAA and company ground communications attempted to contact them. This was unsuccessful and a radio search was then made by several communications stations along the proposed routes, using numerous radio frequencies available to the flights. At 1151 a missing aircraft alert was issued, followed by implementation of search and rescue procedures.

That evening a pilot who operated scenic flights over the Grand Canyon heard about the missing aircraft and recalled having seen light smoke rising out of the Canyon earlier in the day. With his brother, he returned to the area, flew into the Canyon, and during a low pass was able to identify the empennage of the TWA Constellation. He reported the finding immediately and the next day made another flight, during which it was ascertained that there was a second wreckage approximately one mile from the first. There were no signs of survivors on either occasion.

On July 1 an Air Force helicopter from a Search and Rescue unit landed, under hazardous conditions, at the TWA site. After careful consideration, planning, and trial flights, a successful landing was made by an Army helicopter pilot at the United wreckage. On both initial landings, a medic accompanied the helicopter pilot and, after examination, reported that no one had survived either crash. During the following days Army units provided transportation, under extremely hazardous conditions, to and from the sites by helicopter, making it possible to reach the otherwise nearly inaccessible area.

The L-1049 Constellation crashed in a draw on the northeast slope of Temple Butte, which is on the west bank of the Colorado River within the Grand Canyon. The main wreckage site was at an elevation of 3,400 ft. The wreckage was found strewn across the draw along a southwesterly heading, with portions of the nose section on the south bank of the draw and sections of the cabin fuselage on the north bank. A relatively short wreckage distribution path showed that the aircraft contacted the ground at a steep angle.

Distribution and condition of parts indicated the Constellation was inverted at initial impact.

Severe disintegration of the L-1049 occurred during ground impact, followed by an intense ground fire. Together, these caused nearly total destruction of major portions of the aircraft. It was possible, however, to identify a sufficient number of parts to show that with the exception of the L-1049 empennage, portions of the aft fuselage, and light pieces of aft cabin interior, all of the aircraft was at the main wreckage area. Here several pieces of the DC-7 were located. All of these were identified as being parts of the DC-7 left outer wing structure.

The main wreckage area of the DC-7 was located 1.2 statute miles northeast of the L-1049 area. Examination revealed the DC-7 struck the south face of Chuar Butte opposite the Little Colorado River. Impact was about 10 ft. below the top of this ridge at an elevation of 4,050 ft.

Initial impact was on a northeast heading with the aircraft nosed down and its right wing below a level attitude.

Impact forces caused severe disintegration of the DC-7 with major components falling into an inaccessible deep chimney and upon sheer ledges below the impact site. An intense ground fire followed impact. Except for a large portion of its left wing, the DC-7 major components were accounted for by identification of parts and pieces found at or reasonably near the main wreckage.

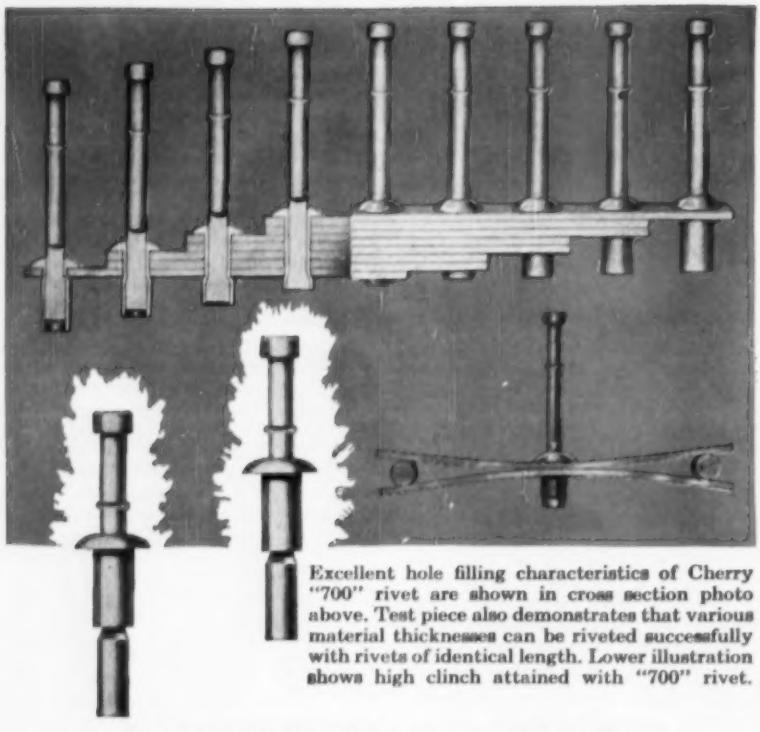
During the difficult and hazardous structural investigation, every effort was made to determine whether or not an inflight collision had occurred and, if so, the manner in which the aircraft collided. Results of this work disclosed several areas of damage which conclusively established that such collision did occur. These areas also provided material for an analytical study relating to the physical relationship of the aircraft to each other at the instant of the inflight impact.

One of the significant areas involved in the inflight contact was the left outer wing panel of the DC-7. Pieces found represented the wing panel from its tip inboard to station 453, a length of about 20 ft. Much of this structure bore evidence of the inflight collision. Some portions of the upper surface, leading edge, and aileron were missing.

DC-7 Wing Panel

The largest single piece of left wing outer panel was found between Temple and Chuar Buttes about one-third mile west of the TWA wreckage site. This piece consisted of the outer portion of the panel from the tip inboard to approximately station 627. To this station the upper and lower wing skin and the leading edge were generally intact. Portions of lower skin were in place for another six feet inboard. Collision evidence in the form of dents, scratches, tears, and bends were found on much of the lower surface of this entire structure. Part of this damage consisted of an upward and inboard deformation in the wing tip cap between the position light and aileron cove. Black rubber smears and red paint smudges were evident at several locations in the deformation. Examination showed the smears on the DC-7 were from the L-1049 deicer boot; also, the paint smudges were from the L-1049.

A fragment of DC-7 wing tip assembly was found separately. This 11-inch piece was part of the aileron cove from the extreme wing tip area. Fragments of top and bottom wing skin were still attached to this piece. Just aft of the tear the tip radius was deformed inboard, rearward, and upward with heavy deposits of L-1049 red paint in the crumpled area. Further, the tip lower surface inboard to the tip attach point was deformed upward and marked by



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scratches running inboard and aft. Also, in this general area on the lower wing surfaces there were numerous black rubber smears and additional scratches. The smears and scratches ran diagonally aft and inboard about 23 deg. in relation to the wing center spar line.

Two pieces of the DC-7 left aileron were found representing the tip area inboard to about station 656. These pieces were severely buckled inboard and upward and both bore heavy deposits of black rubber smears on their lower surfaces.

Between stations 627 and 603 the wing leading edge of the DC-7 was deformed rearward and outboard. Rearward and inboard scratches on the lower leading edge were continuous through areas of deep buckling, indicating they were made before the leading edge struck the object causing buckling. Aft of the leading edge on the lower wing surface there were more scratches running aft and inboard at an angle of approximately 25 deg. relative to the center spar. In this specific area there was no evidence of the black rubber smears.

DC-7 Wing Skin

At the L-1049 wreckage area a section of lower wing skin from the DC-7 was found. This section was from the left wing where the aircraft registration is painted and bore portions of numbers "6" and "3." Scrape marks corresponded directionally to those previously described. Imbedded in a tear on this part was a piece of Constellation headlining used in the aft cabin ceiling. Brown smudges running in the same general direction as the scratches were determined by chemical analysis to be material used to seal Constellation fuselage seams and stringers in the pressure cabin area.

A second area of damage significant to the investigatory objectives and closely allied with the DC-7 wing damage was the Constellation empennage. This major component had struck the ground inverted but came to rest in an upright position about 550 yards north of the concentration of L-1049 wreckage. It was generally intact except for the left and right fins and rudders. Respectively, these were found about 30 and 10 yards removed. This distance of the empennage from the rest of the L-1049, together with the evidence of severe damage where it was separated from the aft fuselage, showed this major components had separated in flight after collision impact. Heavier pieces of the L-1049 aft fuselage structure and aft interior equipment were found west of the main TWA wreckage site. Light interior materials from the aft fuselage were found on Cape Solitude 1¼ miles east, indicating that they were torn or spilled out at a sufficient altitude to drift this distance.

Two pieces from the Constellation empennage were recovered away from the main empennage at sufficient distance to indicate separation prior to ground impact. These, consisting of sections of the left upper fin leading edge and bearing portions of red and white stripes of the Constellation color scheme, showed collision evidence. One piece was concaved on its leading edge, in the area of the red stripe, by an object moving right to left. The concave area fitted precisely with the damage on the DC-7 left wing tip. The red paint found on the wing tip came from this red stripe, and the black marks resulted from contact with the fin

leading edge deicer boot. The second piece, which fitted below the concaved piece, was crumpled to the left by the same force.

The L-1049 aft fuselage was a third area of collision damage. Most significant was a piece of fuselage skin about 1½ x 4 ft. in size. Identification showed it came from the upper right side of the Constellation fuselage just forward of the tail. Its outer surface was painted white. This metal piece was bent inward about 90 deg. so that its inner surfaces were folded toward each other. There were red, blue, and black marks in various directions on the white outer surface paint in the area aft of the bend. In addition to these marks there were gray deposits in a random pattern creating a stippled effect over the entire surface. Together with these there were also long grayish smears progressing in the same direction as the stippling. Pileup of the individual marks within the deposits was heavier on the upper edge. This evidence indicated that the gray deposits were made by an object moving up and along the circumferential frames of the Constellation fuselage.

The final area of important damage was also in the aft fuselage of the L-1049. It was a series of three propeller cuts in the lower and bottom fuselage in the vicinity of the rear baggage compartment. The cuts were generally upward and inboard and of varying lengths. They were essentially parallel about 35 in. apart with the middle cut about 52 deg. relative to the longitudinal axis of the aircraft. Red and blue paint marks at the edge of one cut in the baggage bin area coincided with the paint scheme on the DC-7 propeller.

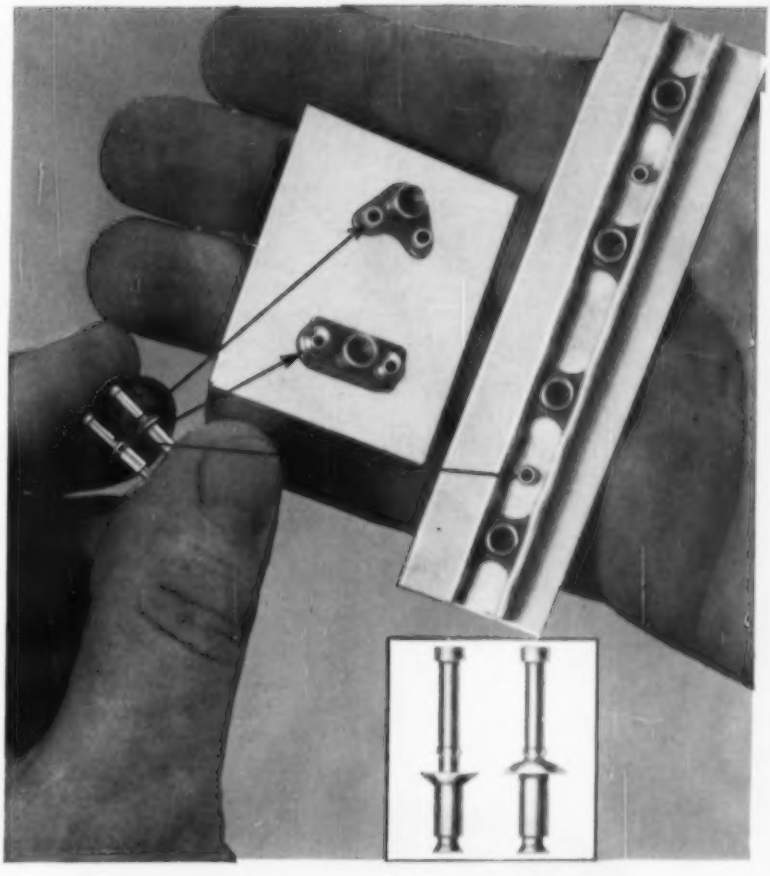
Two additional propeller cuts were located in the L-1049 forward fuselage. One cut was approximately in line with the L-1049 No. 3 propeller arc and the other was about four ft. forward. This damage was not consistent with the other collision damage and the cuts were probably made by the propeller of the Constellation during ground breakup.

Other Areas

Other areas of both aircraft were involved in the collision. Some were secondary or cumulative to the evidence already described and others, although important for other reasons, were not indicative of the inflight impact.

Investigation showed that normal and routine preparations were made for the flights. The TWA Constellation had received a periodic maintenance check at Los Angeles and except for minor discrepancies, not affecting airworthiness, was in good condition. The DC-7 was checked at Los Angeles and at departure there were no mechanical discrepancies or carryover items. The flight engineers had performed preflight and walkaround inspections.

Both flights were planned as high-altitude operations (above 14,500 ft. west of the 100 deg. meridian) which under current regulations and operating specifications permitted them to be planned and flown off airways over direct courses to take advantage of the most favorable weather and wind factors as well as the shortest distance between origin and destination of the long-range nonstop flights. Before flight, however, a definite flight plan is required over the direct route with numerous reporting points indicated to clearly define the proposed



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route to be flown. To this end numerous company high-altitude routes have been established. From these, the most favorable is selected for individual operation.

United Airlines' operational policy permitted a high-altitude flight to be conducted on an IFR or VFR flight plan but the company did not permit its flights to be flown in instrument weather conditions, regardless of the flight plan, during that portion of the flight off airways. In this regard Trans World Airlines' policy, at the time of the accident, permitted off airways flight in instrument weather conditions but only on an IFR flight plan with an assigned altitude. When operating 1,000 on top the company required adherence to visual flight rules.

Briefed On Weather

The pilots were briefed on the anticipated weather conditions before flight time. These indicated conditions well within limits for takeoff and for the planned duration of the flights. Captain Gandy, with nearly 15,000 flying hours, had flown the subject route approximately 177 times and was well qualified. Captain Shirley, with 17,000 hours, had flown the operation since October 1955, and he also was well qualified. Similarly, the other crew members of both flights were experienced. All, according to documentary evidence, were rested, in good physical condition, currently qualified, and certificated for their positions.

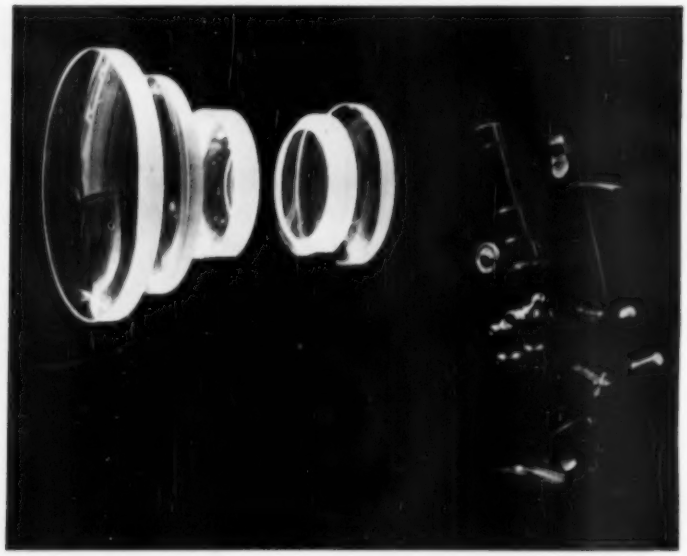
The flights reported in a normal manner as they progressed eastward. Except for the final transmission of United 718, the reports were without indication of any difficulty. The individual company dispatch offices followed the progress of their flight in a regular manner.

Approaching Daggett the TWA flight asked for a change in its flight altitude from 19,000 ft. to 21,000 ft. on its IFR clearance and, if unable, 1,000 on top. The TWA radio operator who received this request from the flight called Los Angeles ARTC and at 0921 advised, "TWA 2 is coming up on Daggett requesting 21,000 feet." The Los Angeles controller then contacted the Salt Lake ARTC controller and said, "TWA 2 is requesting two one thousand, how does it look? I see he is Daggett direct Trinidad, I see you have United 718 crossing his altitude—in his way at two one thousand." According to the recording of this conversation the Salt Lake controller replied, "Yes, their courses cross and they are right together." The Los Angeles controller then called the TWA radio operator and said, "Advisory, TWA 2, unable approve two one thousand." At this time the radio operator interrupted and said, "Just a minute. I think he wants a thousand on top, yes a thousand on top until he can get it." After determining from the flight, through the TWA radio operator, that it was then 1,000 on top the Los Angeles controller issued the following amended clearance, "ATC clears TWA 2, maintain at least 1,000 on top. Advise TWA 2 his traffic is United 718, direct Durango, estimating Needles at 0957." The TWA ground radio operator stated that this clearance was given TWA 2 and it was repeated back to him verbatim by the flight. The operator said that in this transmission he included the information concerning United 718, adding that it was at 21,000 ft. which he concluded from the overall situation although the altitude was not part of the information from the controller. The TWA operator testified that he recognized Captain Gandy's voice and that the captain acknowledged the information on the United flight as "traffic received."

Controllers Testify

The two controllers participating in this action were called to testify at the Board's public hearing. In response to questions they stated that because TWA 2 would soon pass from the Los Angeles ARTC area of responsibility to the Salt Lake area, it was necessary to coordinate the TWA request for altitude change. Both stated that at this time the flights were IFR traffic operating in controlled airspace and ARTC was required to separate them from each other as well as from any other aircraft on IFR clearances. The controller who gave the clearance said he offered the United information to TWA merely as an explanation for the denial of 21,000 and not as a traffic advisory.

The Director of the CAA Office of Air Traffic Control explained that when TWA requested 21,000 ft. the flight had not reached Daggett nor had the United flight reached Needles. They were not traffic for each other at that time but in projecting their tracks eastward both would cross Red Airway 15 with ill-defined horizontal separation. On this airway ARTC was required to separate the flights; thus TWA was de-



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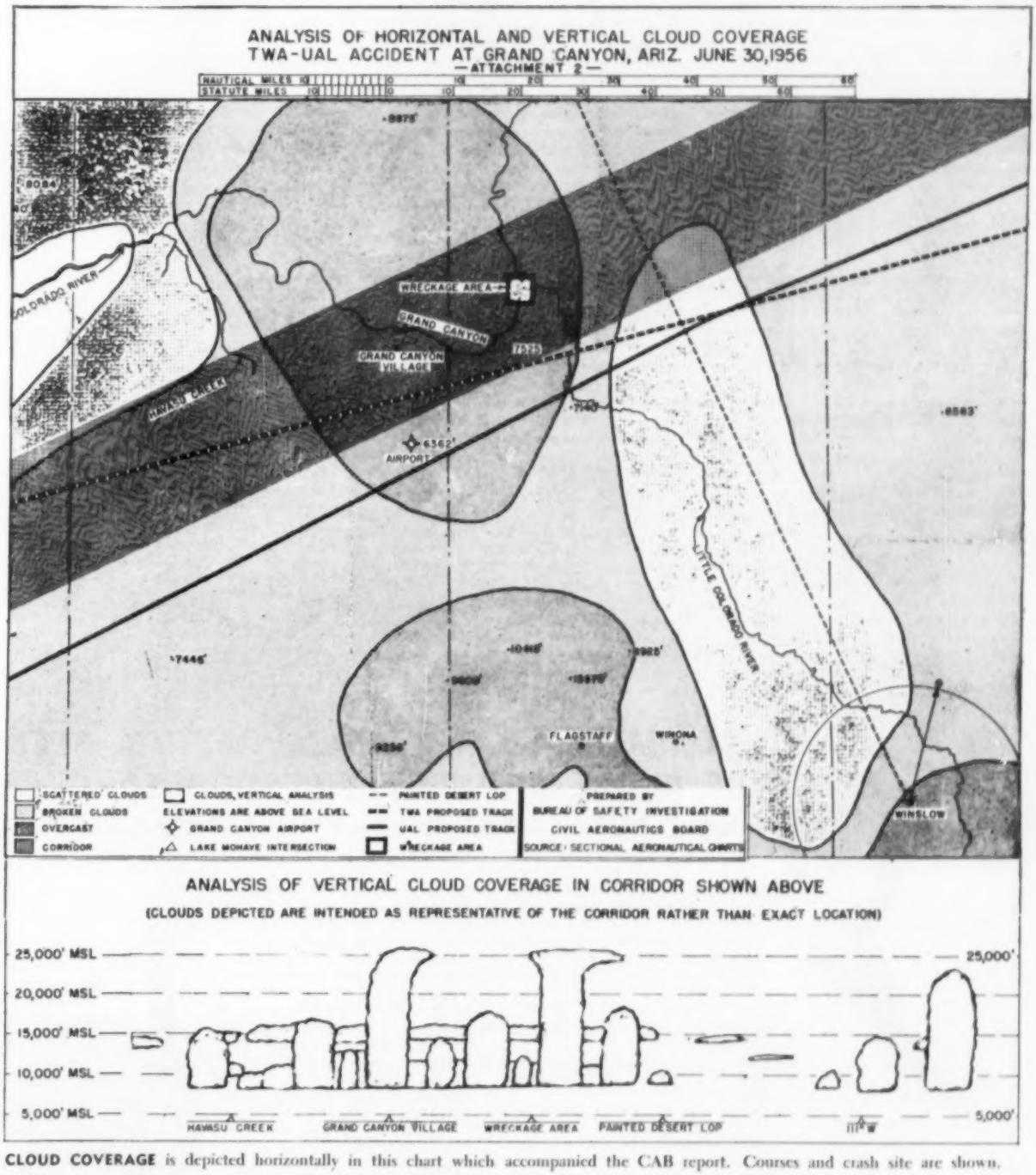

CLOUD COVERAGE is depicted horizontally in this chart which accompanied the CAB report. Courses and crash site are shown.

nied 21,000. The witness added that this separation was an ARTC responsibility for instrument flights only in the controlled airspace and that Red Airway 15 was the last such area for the flights to traverse until they were well beyond the accident scene. He said that ARTC maintains only progress information with respect to IFR flights flying through uncontrolled airspace and that this information is used for the purpose of providing a safely spaced flow of instrument traffic into the next controlled airspace to be entered. He stated that air traffic control does not provide any control service or function in uncontrolled airspace.

The witness explained that flights are not bound by clearance or flight plan, whether VFR or IFR, while operating in uncontrolled airspace and that instrument traffic must only leave and re-enter a control area according to traffic control clearance. The controllers' manual of control procedures (ANC Manual) states that, "Clearances authorize flight within control zones and control areas only; no responsibility for separation of aircraft outside these areas is accepted."

When TWA amended its flight plan from an assigned 19,000 ft. to 1,000 ft. on top, no information concerning this was given to United 718. The Director of Air Traffic Control stated that none was required though the flights were in controlled airspace at the time. The clearance to TWA 2 was to maintain 1,000 ft. on top while it was in a control area. The witness said the flight was not restricted to any specific altitude in control areas except that

it be at least 1,000 ft. above the general cloud layer. When outside controlled airspace and under certain conditions of limited visibility, flight should be conducted at an altitude conforming to the "Quadrantal Rule."[3] The witness stated that the controller therefore did not know what altitude Captain Gandy would select as a cruising altitude or if he might later change the altitude from time to time. The witness stated that with respect to separation the TWA flight at this time was a VFR flight and that the basic VFR minimums applied for it to maintain flight in VFR conditions.[4]

Civil Air Regulations do not provide a definition for 1,000 on-top operation either within or outside controlled airspace; however, with respect to on-top operations in control areas the Flight Information Manual states, "'At least 1,000 ft. on top' (10TOP) may be filed in an IFR flight plan, or assigned by ATC in an IFR clearance, in lieu of a cruising altitude. Even though this type of operation places the responsibility for avoidance of collision with other aircraft on the pilot, the flight is an IFR operation and must obtain an amended clearance for a specific altitude before proceeding into IFR weather conditions." It further states, "Air Traffic clearances which specify 'at least 1,000 ft. above all clouds' in lieu of a cruising altitude permit flight to be conducted at any altitude at or above the minimum en route altitude (MEA) which is 1,000 ft. or more above the cloud layer. . . ."

The present concept for separation of aircraft and avoidance of collision in VFR weather conditions, regardless of flight plan or clearance, depends on the flight crews' ability to provide separation visually between aircraft. Civil Air Regulations expressly place this responsibility on the pilots[5] and the concept is commonly referred to as the "see and be seen" principle. Rules for avoidance and right-of-way are set out in the Regulations also.[6] With respect to an IFR flight operating in VFR weather conditions the Flight Information Manual states, "During the time an IFR flight is operating in VFR weather conditions, it is the direct responsibility of the pilot to avoid other aircraft, since VFR flights may be operating in the same area without knowledge of ATC." In consonance with these provisions the vast percentage of flying today is separated by the "see and be seen" philosophy with little or no external traffic control assistance.

Report at Needles

At 0958 United Flight 718 reported its position to the CAA communications station located at Needles. This report indicated that the flight was over Needles at that time, its altitude was 21,000 ft. and it anticipated reaching the Painted Desert line of position at 1031 (revising the previous estimate of 104). The flight indicated it would thereafter report over Durango. The Needles communicator forwarded this report, according to routine procedure, to the Albuquerque center at 1001 and to the Salt Lake center about 1013. The communicator stated that forwarding the report to Salt Lake was delayed by an interphone tieup. The controller at Salt Lake receiving the report was the one who previously was involved in the decision which denied TWA 2 the request for 21,000 feet as a cruising altitude when the flight was approaching Daggett at approximately 0921.

At 0959 Trans World Flight 2 reported its position to company radio located at Las Vegas. The flight reported it had passed over Lake Mohave at 0955, was 1,000 on top at 21,000 ft. and estimated reaching the 321 deg. radial of the Winslow omni range station (the Painted Desert line of position) at 1031, with Farmington the next reporting position. In response to this the ground communicator repeated back the information, added the barometric pressure for Las Vegas, and told the flight that this pressure was falling rapidly. At 1001 the Las Vegas TWA communicator promptly forwarded this position report over long-line interphone to the Salt Lake center. This report was received by the CAA sector controller at 1001. The same controller received the position report of United 718 at 1013 from the CAA Needles communicator.

During the public hearing the Salt Lake controller and the CAA Director of Air Traffic Control were questioned as to whether or not traffic advisory information

[3] Civil Air Regulations, Part 60.32 (b) 1, 2, 3, and 4.
[4] Civil Air Regulations, Part 60.30 (b) (1).
[5] See CAR Part 60.12 (e).
[6] See CAR Part 60.14 (a) through (c) and CAR Part 60.15.

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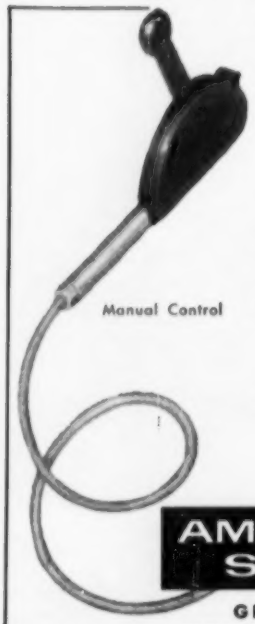

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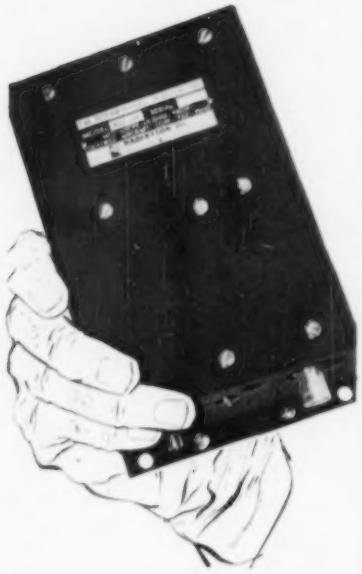

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should have been issued the flights when the controller had received position reports from both flights and knew both were flying at the same altitude, estimating the Painted Desert line of position at the same time on converging courses. The controller stated that when the reports were received by him he had no knowledge of the track that either flight would make to the line of position because both were in the uncontrolled area and a specific track was not required. He said the Painted Desert line of position is nearly 175 mi. long with no definite position within this distance. The estimates from the flights, therefore, did not mean they would converge there but merely that both would pass the line eastbound at that time. He testified that he was not required to give advisory information to flights which were in uncontrolled airspace and it was only a discretionary duty in the controlled area. He also said this advisory service would not be possible as a day-to-day practice without control of flights and more definite position information, as well as additional facilities and personnel.

Director Testifies

The CAA Director of Air Traffic Control testified concerning the situation, stating that it was not the policy or concept of Air Traffic Control to provide traffic information outside of controlled airspace. He said normally such information would be of little value. Many aircraft unknown to Air Traffic Control may be operating in this area; further, Air Traffic Control has no authority over those aircraft that are known. The witness testified that with respect to these two particular flights, the controller certainly knew about them; however, he explained that advisory information must be viewed in its overall application in day-to-day operations. He stated that advisory service for traffic in uncontrolled areas would be tantamount to positive control of all traffic which would require personnel, facilities, and equipment not presently available. He added that this was known to be correct, having several years ago attempted to provide this service on a test and evaluation basis. He added that the workload of an advisory service was found to be nearly equal to that required for a control service. He concluded that the present complement of persons assigned to perform the controller's functions in the uncontrolled areas was not sufficient to offer either an advisory service or perform a control service.

Investigation relating to the progress of the flights shows they were according to the established performance of the aircraft. Both flights made good their estimates between position reports until the segments immediately prior to the Painted Desert line of position; for United from Needles and for TWA from Lake Mohave.

According to the United estimate the flight would reach the Painted Desert at 1031, or 33 minutes after passing Needles. Investigation showed the accident occurred at 1031, approximately 17 mi. or nearly 3½ minutes' flying time from the position of expected progress. Compared to another United flight, 708, a DC-7, which climbed over the same course to cruise at 21,000 ft. approximately one hour earlier, Flight 718 should have reached the Painted Desert

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in its estimated elapsed time. Cruise performance of the aircraft also showed the estimate could have been made.

TWA Flight 2 also was making good its estimates as it climbed toward Lake Mohave. The estimates were in accord with accepted performance of the Constellation and the flight estimated it would reach the Painted Desert at 1031, or 36 minutes after passing Lake Mohave. This flight also was approximately 3½ minutes' flying time from its estimated position when the collision occurred.

Winds aloft were carefully reviewed to determine whether or not they could have been a factor in the delays. It was learned that these winds were light in consideration of altitude and varied little from the winds forecast.

Time of Accident

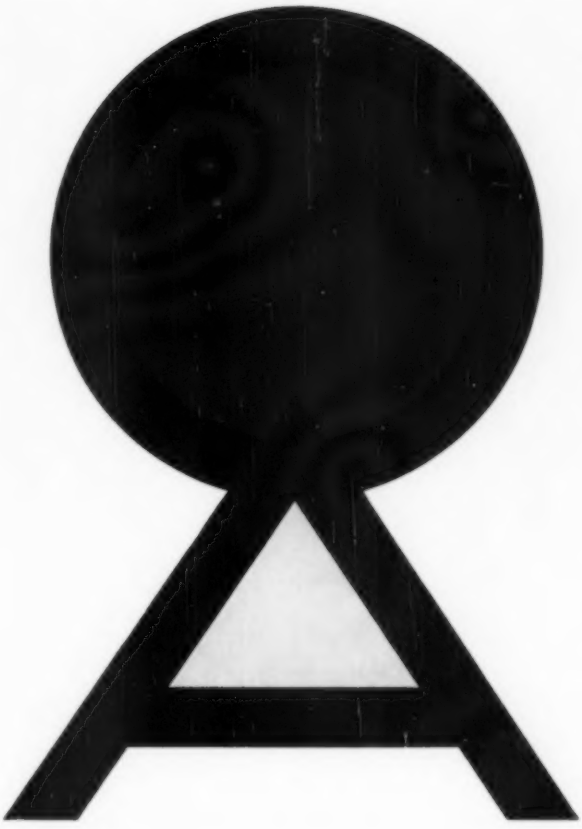
Determination of the time of the accident was an important phase of the Board's investigation. The severe damage sustained by the United aircraft leaves little question but that the aircraft crashed soon after the collision and therefore the last transmission from its crew came very close to the collision time. Knowing the recording that contained the transmission also contained time checks and operated relative to actual time, it was learned that the message began at 1030:53. Pilots who knew the United crew and heard the final message or its transcription felt with reliable assurance that the voice was that of First Officer Harms.

The recorded transmission itself was also examined under laboratory conditions to determine what the exact message was, whether or not anything was said which was inaudible under normal listening conditions, and whether or not the tragedy was reflected during all or just part of the message. The latter objective would assist in determining whether or not the DC-7 crew sighted the L-1049 during the transmission and if the accident occurred during it. The analysis was based on a correlation of the spoken words with a spectographic analysis, a technique used in "Visible Speech." Tests involving binaural listening and speech stretching were also made.

The laboratory results showed the principal speaker said, "Salt Lake, area (or ah), seven eighteen . . . we are going in."[†] During the time represented by the dots a second speaker yelled two known words which were, "up . . . up." This speaker also yelled words which preceded "up." These were indefinite but fitted energy patterns of "look," "pull," or "come." The tests showed clearly that the principal speaker throughout was speaking between 100 and 200 cycles above the normal male voice pitch spectrograms. The background or second speaker's pitch was even higher, being well above that of a female voice; however, it was fairly certain that it was a male speaker. According to the laboratory study both general voice patterns, particularly as to pitch, showed the speakers were under great emotional stress, indicating that they were already in serious trouble.

An exhaustive search for eyewitnesses to the inflight collision was conducted. Many

[†] Differences between initial listening and laboratory results relative to message context are recognized.



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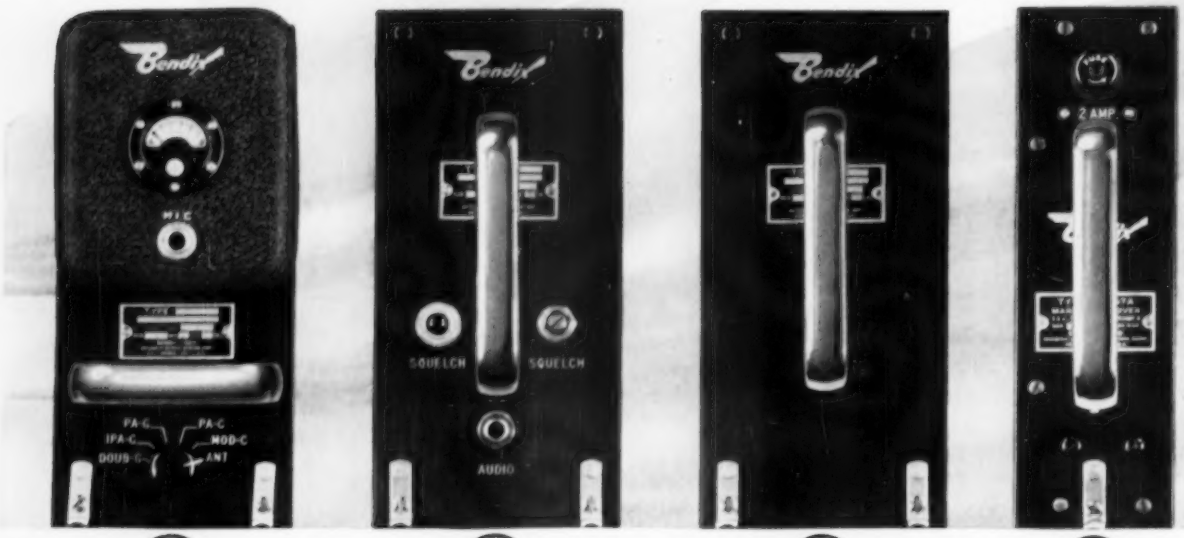

1

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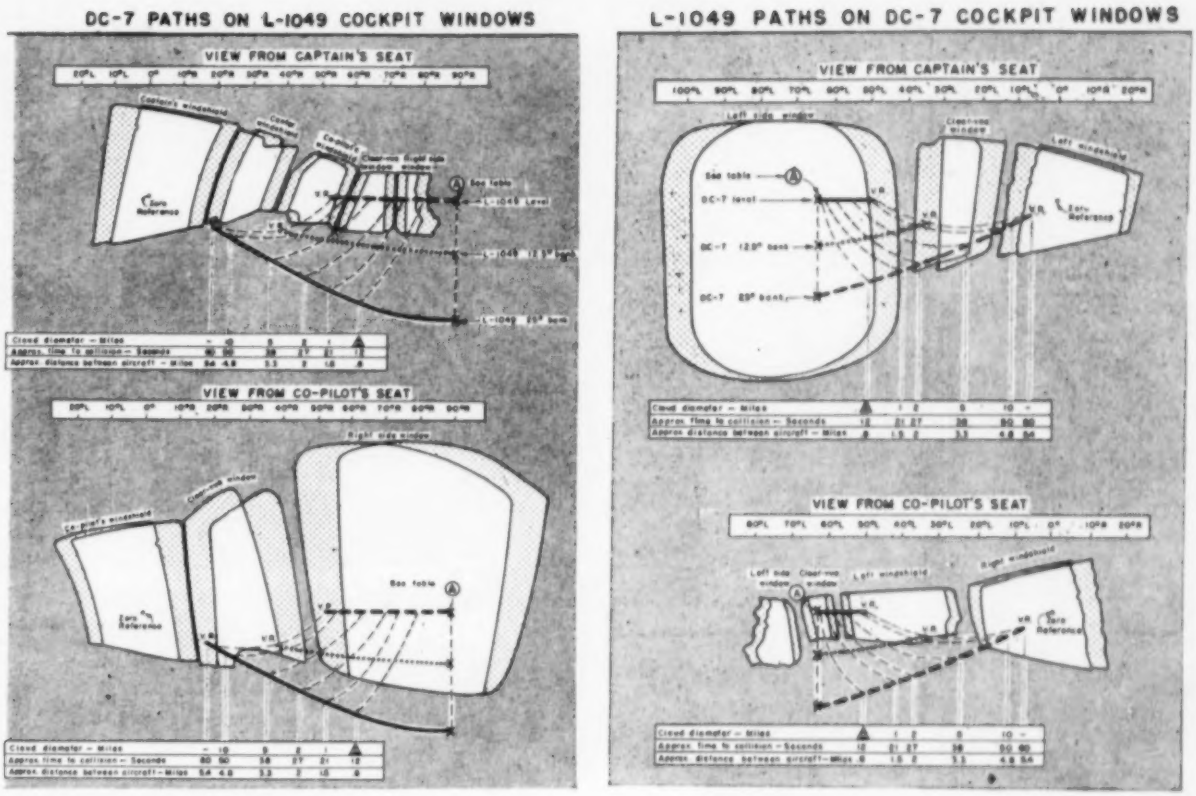

DC-7 PATHS ON L-1049 COCKPIT WINDOWS
VIEW FROM CAPTAIN'S SEAT
VIEW FROM CO-PILOT'S SEAT
L-1049 PATHS ON DC-7 COCKPIT WINDOWS
VIEW FROM CAPTAIN'S SEAT
VIEW FROM CO-PILOT'S SEAT

TABLE: (A) This applies only when both the DC-7 and L-1049 fly straight and level and converge at approx. 25° Position on window is constant at point (A) until instant before collision

Cloud condition and limitation	No clouds and V.R. 5-6 miles	5 miles diameter	2 miles diameter	1 mile diameter	▲
Approx. time to collision — Seconds	120	109	57	27	17
Approx. distance between aircraft — Miles	5.3	4.9	2.5	1.7	4000'

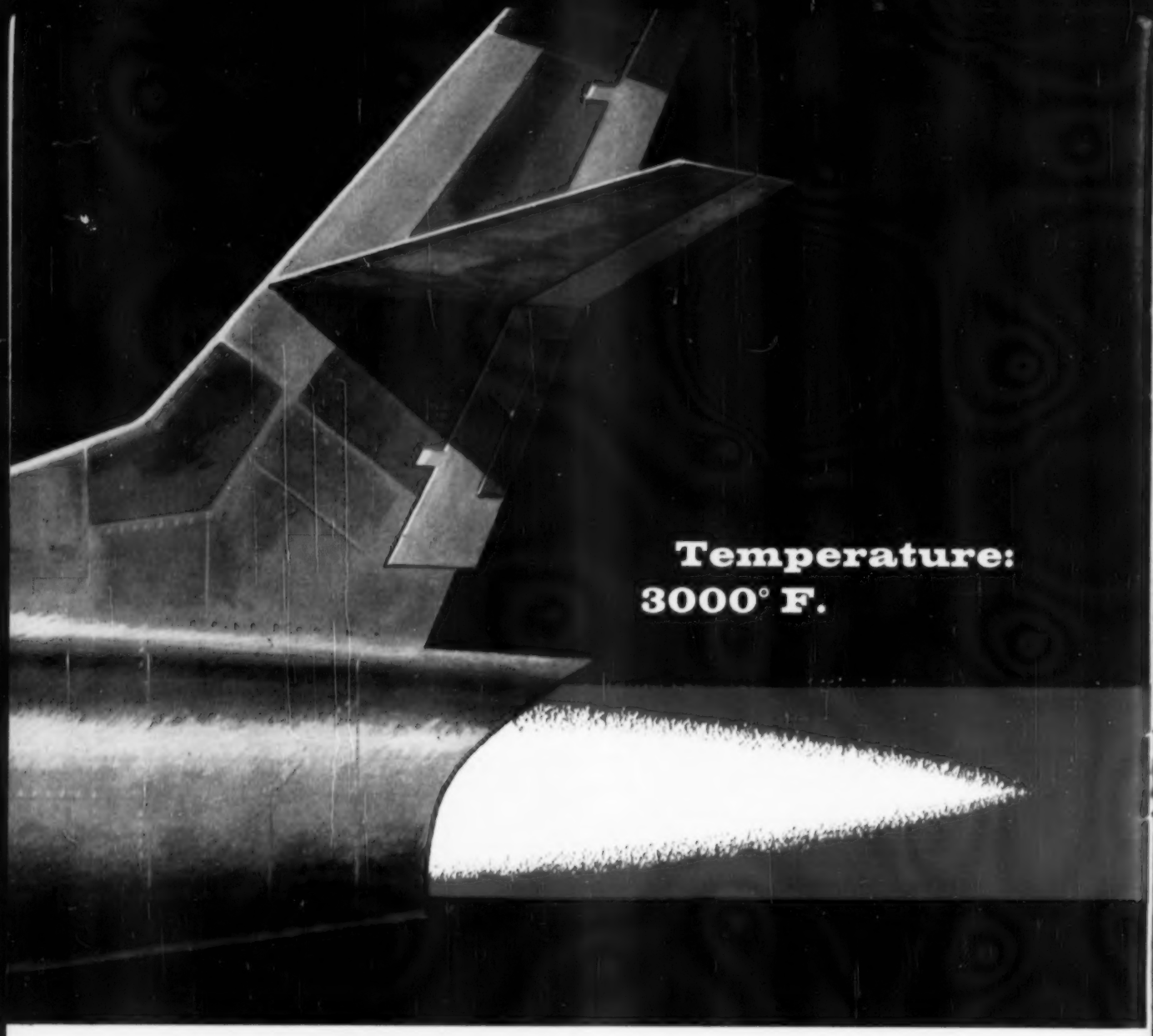
- L-1049 straight and level and DC-7 in right turn at 25° bank
- L-1049 in left turn at 12.5° bank and DC-7 in right turn at 12.5° bank
- L-1049 in left turn at 25° bank and DC-7 straight and level
- X — This point indicates DC-7 position just before collision. Angle changes rapidly in last 1-2 seconds and moves to the right off cockpit window
- V.R. — Point at which the DC-7 first appears assuming a visual range of 5 to 6 miles and with crew positions in cockpit assumed as average
- Monocular vision area — where crew members can see with only one eye
- Clear area within windshield or window outline — crew members can see with both eyes
- Opaque area — area around windshield and side windows with no outside vision
- Dash lines connect corresponding points on three paths shown
- ▲ — Elongated cloud or cloud shelf diminishing eastward to a point

VIEWS FROM COCKPITS of Super Constellation and DC-7 plot visibility of paths of each aircraft in relation to the other.

persons were contacted in the popular tourist area, as were employes of the Grand Canyon Park Service and residents of the surrounding areas. During this search no witnesses were found who saw the collision although at least one person apparently saw smoke from the crashes and dismissed it as a brush fire in the Canyon. Later, on July 10, two witnesses were made known to the Board and were called to appear at the public hearing. These witnesses stated that while driving west on Route 66 between Winona and Flagstaff they saw two aircraft collide. Their descriptions fitted the subject aircraft and especially the Constellation. Both witnesses stated that when collision occurred there was no evidence such as fire, smoke, or falling pieces and that following impact the aircraft seemed to continue on without falling but locked together.

Under intensive questioning, one of these witnesses testified that at the time she saw these two planes she saw them come together. Asked if she saw them collide she said she didn't realize at the time that they had. Questioned further as to how close they came together, she replied, "Too close." She was asked if she observed any space separating the two aircraft and she answered, "Just between the two tails." The witness was asked had she seen the two planes collide would she have said something about it to her husband. She replied that she would have but that she and her husband didn't discuss it. She further stated that she didn't recall her husband saying anything to her about the collision. The witness, a registered nurse, was asked if there had been any thought in her mind that this was a collision wouldn't she have gone to the nearest telephone and made some call to some official body of some authority. She said that she would have.

Investigation showed that the collision occurred a short distance west of and above the wreckage locations, approximately 70 mi. from the witnesses. Calculations and visual capability indicated that at this distance it would be impossible to see dis-



57-45

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tinguishing physical features of the aircraft and nearly impossible to see the aircraft. Relative positions with respect to each other, if visible, would be extremely deceptive. The Board does not question the sincerity of these witnesses but believes they must have seen two other aircraft; several are known to have been operating in this general area. At a considerable distance and at certain angles of observation two widely separated aircraft could well present the illusion of a collision.

Puff of Smoke

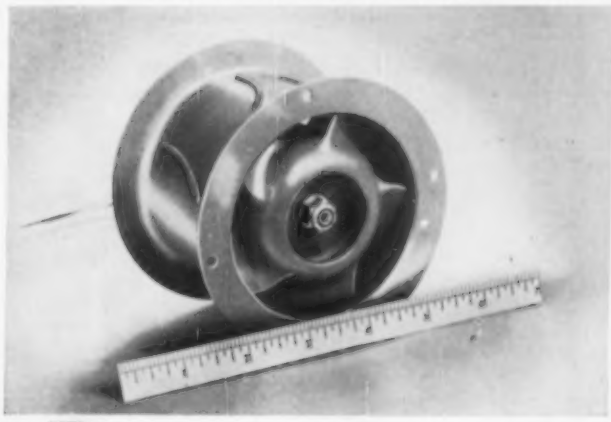
A third witness reported having seen a puff of smoke in the sky over the Grand Canyon area. This witness was near Winslow, about 80 mi. from the accident site, and was also proceeding in a private automobile west on Route 66. The puff of smoke seemed very high and from it two objects appeared to fall on a trajectory path and disappeared into lower clouds. This observation may have been the collision but because little detail could be seen it adds little to the investigatory objectives other than those already clearly established by more positive evidence.

To establish conclusively the importance of the information offered by these witnesses, Board investigators were stationed about 14 mi. east of Flagstaff, the approximate position of the nearest witnesses as indicated by their testimony. On separate days United and Trans World flights flew the proposed routes of Flights 2 and 718, making position reports to the investigators according to a prearranged detailed plan. These were received by a CAA communications truck located with the investigators. Weather conditions on one day were better than those on the day of the accident and on the second day they were equal to or better than the accident day. Results of this work showed that the aircraft could not be seen though their exact positions were known, as were the angles on which to sight to the positions. Many reports and sightings were undertaken. Once a reflective flash was seen and binoculars were trained on it. With this assistance to the observers' normal vision the aircraft could be seen but it could not be identified as to type or make.

The Board was about to publish its report on this accident when, on February 1, 1957, it was advised of another alleged eyewitness to the collision. Shortly thereafter the witness was examined, at length, as to his observations in a deposition taken by the Board.

In substance, the witness testified that on June 30, 1956, while proceeding to Grand Canyon, he made his observations through the windshield of a Ford pickup truck in which he was traveling alone on Route 64 toward Desert View at a speed of 75-80 mph. up a prolonged incline in the road. At the point of observation he was between 5 and 7 mi. south of Desert View or 15-17 mi. south of the estimated collision point.

When questioned as to why he did not make public the fact that he had observed the accident, he answered that he did not want to embarrass himself. Although he had several conversations with persons involved in the investigation of this accident, including Board personnel and personnel



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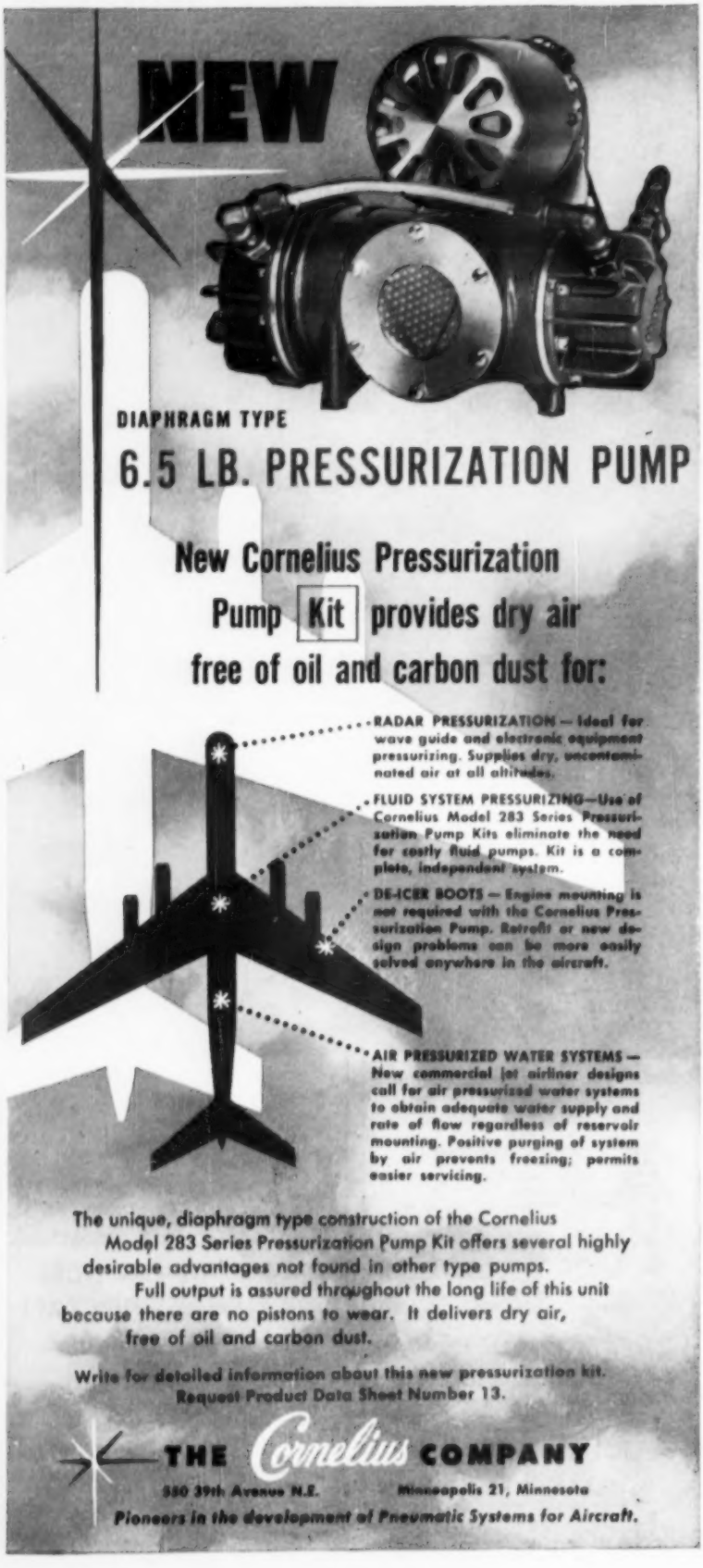
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of the air carriers involved, he did not reveal the fact that he had seen the accident until seven months later.

The Board has carefully evaluated all of the testimony of this witness and concludes that it has no probative value. First, we cannot accept the witness' statement with regard to weather conditions. The record contains full and complete weather information as determined from weather reports, pilot reports, and an analysis of the synoptic situation. This testimony of the witness is in direct conflict with the known weather conditions, as clearly set forth by reliable and probative evidence contained in the record of this case.

Second, with respect to the witness' description of the relative positions and identification of the aircraft, it is unlikely that the witness could have seen these aircraft in the manner and from the place he described. This conclusion is based upon certain tests which were made by the Board immediately after the witness' deposition was taken, and the fact that the witness' observations were made while driving a truck at very high speed.

Under the circumstances, we cannot accept the witness' testimony.

The possibility that both aircraft could have been south of their courses, using the 3½ minutes of unaccounted for time in this manner, is remote. A radius of action computation shows the time to be insufficient to bring the aircraft, especially TWA Flight 2, to a position much closer than 45 mi. to the observers' point and thereafter flown to the known collision position.

The synoptic weather situation consisted of a thermal low centered a short distance northwest of Las Vegas, Nevada. A second low pressure area was centered in Nebraska from which a cold front extended southwestward into northern Colorado, thence westward through central Utah and Nevada as a quasi-stationary front during the day and night of June 29. Aloft the pressure distribution resulted in a southeasterly flow of moist air into northern Arizona. Numerous thunderstorms resulted during the afternoon and night of June 29 which increased the surface moisture. These factors prevailed during June 30 causing considerable low and high cloudiness and showers in the Grand Canyon area but the winds aloft had become more westerly, ranging from south-southwest at 8,000 to west at 21,000 ft. West of this area the routes were clear except for a local coastal stratus condition in the Los Angeles area and some scattered clouds en route but well below flight altitude.

The conditions described were indicated in forecasts made by the United States Weather Bureau and both company weather departments. These predicted there would be high broken clouds with light rain showers in the Colorado River area, the clouds becoming scattered at 8,000 ft. by 1100. Scattered thunderstorms were expected south and east of a line defined from Denver through Milford, Prescott, and Phoenix. These were expected to dissipate in the Arizona and southeastern Utah sector after 0700 but to develop again by 1100. The freezing level was anticipated at 15,000 ft. with light icing and turbulence in the clouds. Moderate to severe turbulence was

Operations engineers Phil Mack and Bob Carter discuss customer interior requirements of the Fairchild F-27 propjet transport.

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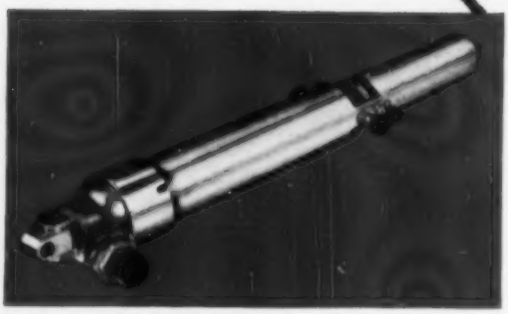

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forecast in the thunderstorms. These buildups were expected to develop to 30,000 ft. or higher, protruding through and above the lower coverage. Top of the lower clouds was anticipated at about 15,000 ft. with good visibility above and outside the thunderstorms. The position of the sun was nearly overhead at 1031 (1131 mst.).

Pilots who flew near the accident area furnished some on-the-spot weather information which essentially supported the forecast conditions. One airline captain passed about 25 mi. southwest of the accident site a few minutes after the accident occurred. He stated that a lower cloud coverage commenced well east of Las Vegas with increasing coverage from Havasu Creek eastward, becoming nearly overcast 20-25 miles west of Grand Canyon Village. Cruising at 19,000 ft. he noted several towering cumulus clouds, one of which was located over the immediate Grand Canyon Village area and others farther east and northeast. He saw no buildups west of Grand Canyon Village. He estimated the height of these to equal or exceed 25,000 ft. and stated that they appeared to still be in the active or building stage. He was unable to estimate the size of the thunderstorms relative to diameter, length, or width. Below, he said, the top of the overcast was approximately 15,000 with few breaks but recalled one such break through which he saw Grand Canyon Airport, located 25 miles southwest of the accident site. The captain stated that he operated clear of clouds with no difficulty as he passed west and southwest of the accident site.

Other pilots flying below the overcast over the Grand Canyon saw a shaded rain area to the west. One pilot said there were breaks in the overcast with excellent visibility below it. He added that the condition described existed in all directions to the limit of his visual ability. Through the breaks he noted no evidence of any appreciable buildups.

ANALYSIS

The several areas of damage previously described formed the foundation for a successful although arduous analytical study relative to the inflight collision sequence, the extent and effect of the collision damage, and the relative attitudes of the aircraft at the instant of impact.

The initial impact occurred with the DC-7 moving from right to left relative to the L-1049 and with the L-1049 moving to the right and aft relative to the DC-7. From analysis of physical damage in consideration of locations of the damaged components of the aircraft, it appears that first contact involved the center fin leading edge of the L-1049 and the left aileron tip of the DC-7. Instantly thereafter the lower surface of the DC-7 left wing struck the upper aft fuselage of the Constellation with disintegrating force. Without question this force caused complete destruction of the aft fuselage and destroyed the structural integrity of the left wing outer panel. As this occurred and the aircraft continued to pass laterally, the left fin leading edge of the Constellation and the left wing tip of the DC-7 made contact, tearing off pieces of both components. During this same time the DC-7 No. 1 propeller inflicted a series of cuts in the area of the aft baggage compartment of the L-1049. This entire sequence occurred in less than one-half second and in such a manner that an interlocking of the aircraft was virtually impossible.

From the extent of damage and the locations of various components on the ground, the collision ripped open the fuselage of the Constellation from just forward of its tail to near the main cabin door. The collision also caused the empennage of the Constellation to separate almost immediately. This aircraft then pitched down and fell on a short forward trajectory to the ground. Consideration of these factors leads the Board to conclude that the collision occurred in space over a position just west of the TWA crash site.

The United aircraft appears to have sustained lesser but equally critical damage affecting flight. Most of its left outer wing separated during the collision and it appears likely that the horizontal stabilizer of the DC-7 was struck by pieces torn off the Constellation. It is also reasonable that damage to the left wing restricted aileron control. It is believed that the DC-7 fell less steeply, probably on a turning path, to the ground.

For damage to have resulted as described earlier and for other areas to have escaped inflight contact, the aircraft had to be oriented in a certain manner relative to each other when the collision occurred. Additionally, and independent of the matching of damage, a study was also made relative to the propeller cuts. Both studies gave nearly identical results relative to the angle between the aircraft at the instant of impact. This angle was found to be approximately 25 deg. relative to the longitudinal axes.

From the layout work matching the inflight contact areas, it was determined that the DC-7 left wing was above the L-1049 relative wing plane or the DC-7 was rolled approximately 20 deg. right wing down relative to the L-1049. The study also indicated the aircraft were oriented such that the vertical distance between empennages of the aircraft was less than the vertical distance between their nose sections. The difference as an angle was between 5 and 10 deg. It is important to recognize that the aircraft attitudes described are relative or with respect to each other and do not necessarily reflect their orientation with respect to the ground.

Because some components of the aircraft were not recovered and others were destroyed, it was not possible to determine completely whether or not any malfunction occurred to either aircraft before impact. From all that could be examined there was no evidence of malfunction and from all the evidence surrounding the accident the Board believes there was none.

Analysis of all the available weather information, including pilot reports, indicates that the forecast conditions for the flights were reasonably accurate. It shows that the two flights departed Los Angeles and climbed through an overcast approximately 700 ft. thick to clear conditions on top. The overcast was local in nature and confined to the Los Angeles coastal area. Thereafter, the flights, except for some scattered clouds, were in clear weather as they climbed eastbound over their respective tracks.

Clear weather appears to have prevailed east of Las Vegas along the Colorado River to near Havasu Creek but becoming overcast with a few breaks beginning a short distance east of Havasu Creek. Along the proposed routes of TWA 2 and UAL 718, scattered clouds commenced shortly east of the California-Arizona border. Eastward therefrom clouds increased to broken, then overcast with some breaks in the Grand Canyon area to somewhat east of the accident site. Tops of this main weather coverage were approximately 15,000 ft. with several lower layers, the lowest being about 2,000 ft. above the ground.

Northwest of Grand Canyon Village, or over the western portion of the main Grand Canyon, the first of several scattered buildups appears to have existed. It appears to have been isolated with others northeast of it. The buildups were apparently formed in the lower clouds and protruded through and above them to approximately 25,000 ft. An airline captain described the westernmost buildup as large but of an indeterminable width and length. He believed it was almost over Grand Canyon Village. Pilots below the overcast saw no evidence of it there but at least two noted a rain area northwest of this position. It is entirely likely that the rain area was from the buildup noted by the captain from above. Pilots flying below the overcast also stated that they saw breaks in the overcast but that they were few and scattered. They observed that the overcast condition covered most if not all of the Grand Canyon.

From the evidence available the Board is of the opinion that the weather conditions at 21,000 ft. would not have precluded flight in VFR conditions in this accident area but that deviations may have been required to circumvent the buildups while the subject flights traversed the area.

Flights Were VFR

According to company procedures, United flights were not permitted to fly in instrument weather conditions while operating off airways. Similarly, TWA procedures precluded instrument flight under the flight clearance on which its Flight 2 was proceeding at the time of the accident. Each company, under the conditions during which this accident occurred, therefore required its flight to adhere to visual flight rules. Further, it is unlikely that Captain Gandy would proceed into instrument weather conditions, having previously been informed that the United flight was in the general area at 21,000 ft. The Board is therefore of the firm opinion, based on the weather conditions, company procedures, and good pilot practice, that both flights were operating according to rules prescribed for VFR conditions when the collision occurred.

The last position report from each flight indicated, at the time the report was given, that each was at 21,000 ft. Although there was no requirement for either to remain at that altitude in the uncontrolled area, with respect to Air Traffic Control, each company did require that it be notified of an altitude change. Because there was no notice and no known reason for the flights to alter altitude, it is considered reasonable to believe that the collision occurred at 21,000 ft.

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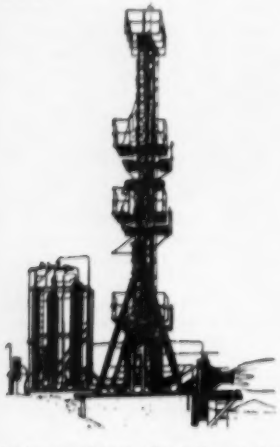

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Painted Desert, together with aircraft performance, it appears that both flights should have reached the line of position about 17 mi., or 3½ minutes' flying time, farther east when the accident occurred. Although there are several possibilities, no definite conclusion has been reached as to the cause of the 3½ minute delay of these aircraft. One possibility is that it could have been caused by maneuvering to provide a more scenic view for the passengers, although the evidence is not sufficient to establish this fact. Another possibility is that a less favorable wind was encountered during the subject segments than was used for estimates which slowed the progress of the flights. A third possibility is that one or more buildups in the Grand Canyon area may have required deviations, accounting for the time.

At approximately 1013 the Salt Lake controller was in possession of the last position report made by each of the subject flights. He was then aware that when the reports were made both aircraft were operating at 21,000 ft., were on converging courses, and were estimating the Painted Desert at the same time. He advised neither flight of this situation. In considering whether or not this should have been done, the traffic control concept, the controller's express duties, and the requirements involved to provide this information to flights must be considered.

Air Traffic Control undertakes to separate air traffic when it is operating in accordance with an IFR clearance and while it is within the confines of controlled airspace. If instrument weather conditions exist and the above requirements are met, all air traffic would be separated. However, when visual flight conditions exist instrument traffic is separated only from other like traffic and not from aircraft being flown under visual flight rules, much of the latter being unknown to Air Traffic Control. For this reason flights in visual conditions are required to provide their own separation regardless of flight plan or clearance.

Uncontrolled Airspace

Outside the controlled airspace the air traffic control concept has not embraced the responsibility for separation of air traffic regardless of flight plan, clearance or weather conditions. In this area no control is exercised by Air Traffic Control, its principal function being to monitor the progress of flights through an uncontrolled area so that an orderly flow of instrument traffic may be accomplished into the adjacent control area. Control is not presently available in the uncontrolled airspace because facilities and means do not exist.

At the present time traffic advisory information to flights is offered when and where control of air traffic is being exercised. Then, such advisory is discretionary with the controller and is not a mandatory procedure of control. Accurate and worthwhile traffic information requires that the controller be informed of the aircraft involved and have precise and timely information on the position of flights relative to their altitude and lateral and forward position along a defined track. This information must thereafter be posted and correlated with like information on other flights to determine whether or not a conflicting situation exists. In the uncontrolled airspace, as previously stated, flights are permitted greater flexibility to take advantage of wind and weather factors. Further, in this area the navigational aids enabling a flight to report its position with the precision necessary to enable accurate advisory information are insufficient. The aforementioned factors affecting the value of traffic advisory information are evident with respect to TWA 2 and United 718. Both flights were somewhat north of their proposed tracks, both were approximately 17 miles west of where they had estimated they would be at that time, and their actual tracks intersected a considerable distance before the proposed tracks converged. Such deviations are not unusual off-airways.

Although knowledge of the projected flight paths of the subject flights could have prompted the Salt Lake controller to offer both flights traffic advisory information on a voluntary basis, giving the best information available to him at the time, the Board is of the opinion that the existing control concept, Air Traffic Control policies and procedures, and the express duties of a controller did not require him to do so.

Means With Pilot

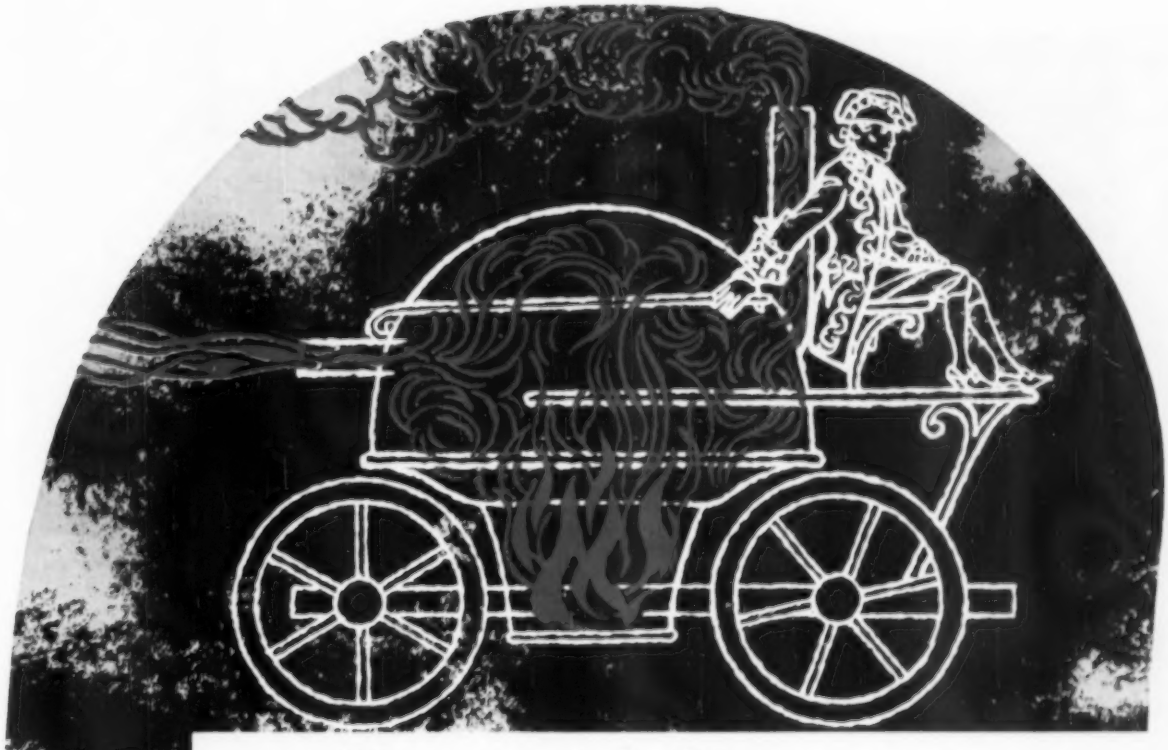
This accident, as nearly all other midair collisions, apparently occurred in visual flight weather conditions and there is no reason to believe the aircraft were not being operated in accordance with cloud separation criteria of visual flight rules. Under these conditions and according to these rules the vast portion of flying today is being conducted. Accordingly, the present means for avoiding collision rests with the pilot to see and avoid other aircraft.

Extensive study of most collision accidents has shown that there was an opportunity, of varying degree, for the pilot or pilots to see the conflicting aircraft in sufficient time for them to take evasive maneuvers to avoid the accident. In many of these accidents where there was survival, however, testimony of the pilots was that they were maintaining a careful lookout but despite it they did not see the other aircraft in time to avoid it or that they did not see it at all.

Collision studies, including controlled flight tests, have pointed out that seeing other aircraft in flight is difficult. The degree of such difficulty is variable with numerous tangible and intangible factors affecting it. The first tangible factor is the angular limits of cockpit vision, or the vision afforded by cockpit structure and design only.

The second tangible factor is visual range or the distance that an object can be seen. Many conditions and circumstances enter into this factor and are variable. Some of these are color of the object, its background, and the contrast between them. Others are mass of the object, its angular size and shape, and the atmospheric condition of visibility. The latter may also include altitude effect and cloud obstruction.

A third group of factors is physiological or human and many of these are intangible, depending on the individual's physical condition, degree of fatigue, and training. The human eye will best see an object when it is within the sensitive or focal field of vision, which is two or three degrees. An object may be seen through the peripheral portion of vision or the area of several degrees outside focal field. The number of



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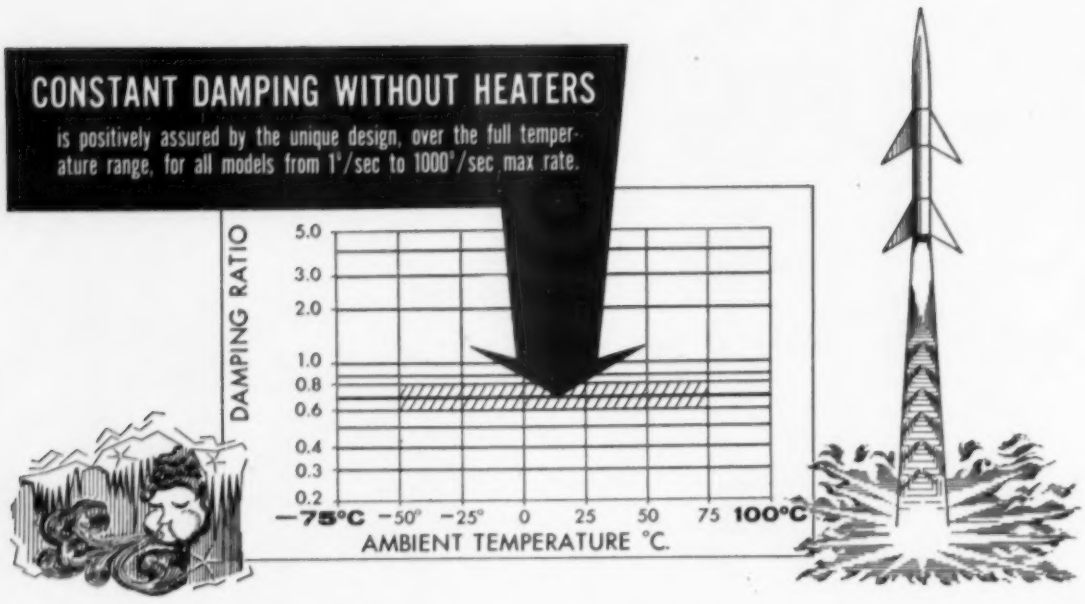

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degrees is dependent upon motion and/or the aforementioned factors providing sufficient stimuli. It may be noted that aircraft converging on constant, unvarying collision courses provide no relative motion when viewed from the aircraft. Searching for aircraft within the visual limits of cockpit visibility requires scanning through those limits. This requires time, the amount being allied to the physiological factors and the adequacy depending on all considerations, including closure speed.

Allied to the element of opportunity it is important to recognize that the operation of a modern aircraft requires regular and frequent attention of the pilot or pilots to duties within the cockpit. Attention to instrumentation, both operational and navigational, is required during all phases of flight, as well as computations and records pertaining to the progress and anticipated progress of the flight.

Many combinations of adverse factors, conditions, and circumstances can result in a limited opportunity to see another aircraft. On the other hand the opportunity to see another aircraft may be good. Here the factors act to a good and reasonable opportunity for the vigilant pilot and in this regard the Board expects pilots to maintain the highest degree of vigilance.

It is recognized that the basic means for traffic separation in VFR conditions is presently the "see and be seen" philosophy. This concept has existed as a matter of necessity, with its known limitations, and will continue until there are sufficient technological advances to provide additional assistance to the pilot for collision avoidance. The progress of aviation is moving rapidly toward higher altitudes and greater speeds, with traffic in increasing density. Fully aware of this and its effect the Board is lending its support to industry, other governmental agencies, and interested persons to find and develop methods, means, and devices which will assist the concept of visual separation.

Insufficient Evidence

Knowing full well that insufficient evidence would preclude determining with positive results the existing opportunities for the subject crews to see the conflicting aircraft, the Board nevertheless conducted an exhaustive analysis. This was done to present all information possible from the available evidence. The analysis was successful in this objective and disclosed much which the Board believes will assist its principal goal of greater safety in aviation.

Since the attitudes of the aircraft relative to the ground and their probable flight paths prior to collision are so closely interrelated, they can be treated together. A determination of these is imperative relative to the opportunity for the pilots to have seen the conflicting aircraft.

As indicated, correlation of the physical damage relates one aircraft with respect to the other and not with respect to the ground. Obviously, the physical orientation is valid only at the instant of impact. Because of this, and in the absence of eyewitnesses, it is not known whether one or both aircrafts were rolled, pitched, or yawed relative to the ground. Without a known orientation of at least one of the aircraft with respect to the ground, an analysis cannot determine a single flight path of the aircraft prior to the collision, nor is it possible to establish the flight paths by other known factors in this accident. It is therefore necessary to evaluate the objective on the basis of several flight path combinations, knowing that only one existed. Generally, however, the possibilities may be narrowed into two broad categories with variations. The possibilities may also be limited by the known orientation of the aircraft to each other at the instant of impact, which precludes certain other relative attitudes between the aircraft.

Three Variations

The first category assumes that there was no evasive action prior to collision and that one or both aircraft were turning within the limits afforded by the known collision orientation. This category accepts as reasonable that both aircraft were being flown commensurate with their performance for the en route phase of flight. Analytical studies recognized the variations to this category but found that three limit considerations seem to cover the infinite number with respect to the pilot's visual opportunities. Two of these are that either aircraft was turning while the other flew straight and level to collision; the third is that both were turning prior to the accident.

The second category of possibility is based on the assumption that there was an evasive action initiated by one or both flights but that it came too late to avoid the accident. Again, it is reasonable to believe the evasive action was limited to the known orientation and that the aircraft were being flown according to the normal performance for the en route phase of flight. The evasive action was also limited to aileron-elevator type maneuvers. Although rudder displacement was studied and evaluated the aileron-elevator action appeared to be more consistent with the preponderance of all evidence; however, this was not entirely conclusive. Even accepting this limit there are variations, but these can be narrowed by a limit consideration. This is possible because maneuver characteristics of both aircraft showed that an evasive action without sufficient time to avoid the collision would not be appreciably alter the flight path of either aircraft from flight paths which presumed there was no evasive action. It must be noted, however, that relative attitudes of the aircraft would be changed. Accordingly, the studies under the second category relating to the visual opportunities of the crews are not appreciably altered from the situation where both aircraft were approaching one another in straight and level flight at the angle between the longitudinal axes shown to have existed at the initial impact, 25 deg.

It is known that several cloud buildups existed in the immediate area of the collision and their heights extended well above the cruising altitudes of both flights. Although it is unknown, it is entirely possible that the aircraft may have been flown so that one was on each side of a buildup shortly before collision. The effect of this would, of course, preclude the crews from seeing the other aircraft during the time the cloud or clouds were between them. Clouds would also require course deviation in certain situations. They would also seriously

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limit the time for pilots to see the conflicting aircraft, the amount depending on the size and shape of the clouds, the lateral distance maintained by the flights from them, and the distance of the clouds from the collision point. Thus, a cloud positioned close to the collision point would limit the time opportunity as would one which was narrow or elongated. The intervening cloud factor appears to be a possibility and therefore was a necessary consideration in the visual opportunity study. To this end several representative cloud sizes and shapes were selected and introduced in the analytical study. The study also included the consideration which presumed that clouds would not have been a factor. The study accepted as the limit of visual range a distance of five to six statute miles and assumed that the aircraft passed the cloud formation at a horizontal distance of 2,000 ft. and that they were at the same altitude.

The results of this analysis were then applied to the individual crew members from their respective cockpit positions. This was accomplished in the form of windshield displays, thereby incorporating the several situations with the angular limits of cockpit vision.

Captain's View

From the display it is apparent that the L-1049 was within the angular limits of the DC-7 window area from the captain's seat during all the flight path situations. In the situation of no intervening clouds, motion would be involved in three of the four situations. Windshield formers would block the captain's view for varying portions of the time opportunity. The time opportunity with no clouds was 50 to 120 seconds according to the situation being considered. The worst cloud situation could reduce the time opportunity to as low as 12 seconds.

With respect to the DC-7 first officer's position, the L-1049 was within the angular limits of the DC-7 window area during two of the limit considerations and during the early part of the other two. In the "no cloud" factor situations the L-1049 would have been near maximum visual range in two conditions, without relative motion in one, and with relative motion in another. Time opportunity without intervening clouds and with both aircraft straight and level was 120 seconds. For the other three considerations, including the intervening cloud condition, the opportunity varied from 12 seconds to 50 seconds.

In only one of the conditions does it appear that the L-1049 captain could have seen the DC-7 from his seat; in this the opportunity was for a period of up to 40 seconds with no intervening clouds. In the other three conditions, according to the study, his opportunity was precluded by the limits of cockpit structure or because the DC-7 was beyond visual range.

The study indicates that without the intervening cloud condition the DC-7 was within visual range and within the angular limits of cockpit vision from the L-1049 copilot's seat during three of the four flight path situations. Then the time opportunity varied from 50 to 120 seconds, according to the situation. Two of the displays reveal relative motion. Again, in the worst cloud situation his time opportunity was as low as 12 seconds.

Analysis of the various possible flight path variations relative to cockpit angular limits of vision has shown that one or both pilots of one aircraft could have been precluded from seeing the conflicting aircraft during critical periods. The study must also recognize the possible effect if one crew member was occupied with cockpit duties and he alone had the visual opportunity during this time.

Clouds in Area

The Board has shown the existence of cumulus-type clouds in the accident area. It has shown that these clouds may not have been an intervening factor between the flight paths of the aircraft. Here the time opportunities for the pilots to effect visual separation were good. In this situation, despite the possible flight path variations, and in consideration of the aforementioned factors controlling visual ability of the pilots, the Board is of the opinion that the range of opportunities was adequate.

If this situation existed, the Board believes the pilots should have seen and avoided the other's aircraft.

On the other hand, evidence has shown that during other of the possibilities the pilots' opportunity to effect visual separation could have been seriously impaired. Analysis has shown how clouds, if positioned between the flights at a critical time, could have reduced the time opportunity for collision avoidance to less than the minimum of 15 or more seconds necessary for scanning, pilot reaction, and airplane response.

The Board has carefully studied and arduously evaluated all the available evidence surrounding this accident. It has learned all that existing methods of investigation and evaluation enabled it to do. This was done without the assistance of survivors or eyewitnesses whose testimony is considered imperative to a complete knowledge and to single conclusions in the collision-type accident.

Because of the lack of this vital information and when all factors, including intervening clouds, cockpit visual limitations, cockpit duties, the several flight path variations, the time opportunities, and the physiological limits to human vision are considered, the Board concludes there is not enough evidence to determine whether or not there was sufficient opportunity for the pilots to avoid the collision.

FINDINGS

On the basis of all available evidence the Board finds that:

1. The companies, the aircraft, and flight crews were properly certificated.

2. Preparation for both flights was complete and routine.

3. The flights were properly dispatched on IFR flight plans, over accepted high-altitude direct routes.

4. Approaching Daggett, TWA 2 requested its company radio to obtain 21,000 ft. as an assigned altitude, or 1,000 on top.

5. Company radio requested 21,000 ft. IFR from ARTC. This was denied by ARTC. Request was then made for 1,000 on top. This was approved and clearance issued. The flight climbed to and proceeded at 21,000 ft.

6. As an explanation for the denial of 21,000 ft., TWA 2 was furnished pertinent information on UAL 718.

7. The last position report by each flight indicated it was at that time at 21,000 ft., estimating the Painted Desert line of position at 1031.

8. The Salt Lake controller possessed both position reports at approximately 1013, at which time both flights were in uncontrolled airspace.

9. Traffic control services are not provided in the uncontrolled airspace and according to existing Air Traffic Control policies and procedures the Salt Lake controller was not required to issue traffic information; none was issued voluntarily.

10. A general overcast with some breaks existed at 15,000 ft. in the Grand Canyon area.

11. Several cumulus buildups extending above flight level existed; one was nearly over Grand Canyon Village and others were north and northeast in the area of the collision.

12. The collision occurred at approximately 1031 in visual flight rule weather conditions at about 21,000 ft.

13. The collision in space was above a position a short distance west of the TWA wreckage area, 17 mi. west of or approximately 3-½ minutes' flying time from the Painted Desert line of position.

14. Under visual flight rule weather conditions it is the pilot's responsibility to maintain separation from other aircraft.

15. At impact the aircraft relative to each other converged at an angle of about 25 deg. with the DC-7 to the right of the L-1049. The DC-7 was rolled about 20 deg. right wing down and pitched about 10 deg. nose down relative to the L-1049.

16. There was no evidence found to indicate that malfunction or failure of the aircraft or their components was a factor in the accident.

PROBABLE CAUSE

The Board determines that the probable cause of this mid-air collision was that the pilots did not see each other in time to avoid the collision. It is not possible to determine why the pilots did not see each other, but the evidence suggests that it resulted from any one or a combination of the following factors: Intervening clouds reducing time for visual separation, visual limitations due to cockpit visibility, preoccupation with normal cockpit duties, preoccupation with matters unrelated to cockpit duties such as attempting to provide the passengers with a more scenic view of the Grand Canyon area, physiological limits to human vision reducing the time opportunity to see and avoid the other aircraft, or insufficiency of en route air traffic advisory information due to inadequacy of facilities and lack of personnel in air traffic control.

By the Civil Aeronautics Board:

James R. Durfee
Chan Gurney
Harmar D. Denny
G. Joseph Minetti

Member Louis J. Hector did not take part in the adoption of the report.

SUPPLEMENTAL DATA

The Civil Aeronautics Board was notified that the aircraft were overdue and were

assumed to be down at 1500, June 30, 1956. Investigators were promptly dispatched to the carriers' search headquarters where notice was received that the wreckages were located in the Grand Canyon. An investigation was immediately initiated in accordance with the provisions of Section 702 (a) (2) of the Civil Aeronautics Act of 1938, as amended.

A public hearing was ordered by the Board and was held in the Department of Commerce Auditorium, Washington, D. C., on August 1, 2, 3, and 4, 1956.

Air Carriers

Trans World Airlines, Inc., a Delaware corporation, is a scheduled air carrier with its principal offices located at Kansas City, Missouri. It possesses a currently effective certificate of public convenience and necessity issued by the Civil Aeronautics Board and an air carrier operating certificate issued by the Civil Aeronautics Administration. These authorize the carrier to transport by air persons, property, and mail over various routes including that from Los Angeles, California, nonstop to Kansas City, Missouri.

United Air Lines, Inc., is a Delaware corporation with its corporate offices in Chicago, Illinois. The company is engaged in transporting by air persons, property, and mail.

It holds a currently effective certificate of public convenience and necessity issued by the Civil Aeronautics Board and an air carrier operating certificate issued by the Civil Aeronautics Administration.

These authorize operation over a number of routes including that from Los Angeles to Chicago.

Flight Personnel

• **Trans World Airlines.**

Capt. Jack S. Gandy, age 41, was employed by the company December 26, 1939, and became captain in March, 1942. He held a valid airmen certificate currently effective airline transport and Lockheed 1049 ratings. Captain Gandy had a total of 14,922 flying hours, of which 7,208 were in the Lockheed 1049. His rest period prior to Flight 2 of June 30, 1956, was 16 hours. Captain Gandy was qualified over the subject route and had flown it 177 times. His last proficiency check was January 10, 1956, and his last physical, first-class, was completed, without waivers, April 5, 1956.

Copilot James H. Ritner, age 31, was employed by the company on June 2, 1952. He held a valid airman certificate with multiengine and instrument ratings. His total flying time was 6,976 hours, with 825 hours in the equipment involved. His last physical examination was dated August 23, 1955, and he received an 18-hour rest period during the 24 hours prior to Flight 2 of June 30, 1956.

Flight Engineer Forrest D. Breyfogle, age 37, was employed by Trans World Airlines October 1, 1945. He held a currently effective mechanic certificate with airframe and engine ratings, a flight engineer certificate, and a radiotelephone permit. Mr. Breyfogle had accumulated 7,896 flying hours, of which 7,237 were in the equipment involved.

His last physical examination was received on May 25, 1956.

Flight Engineer Harry H. Allen was

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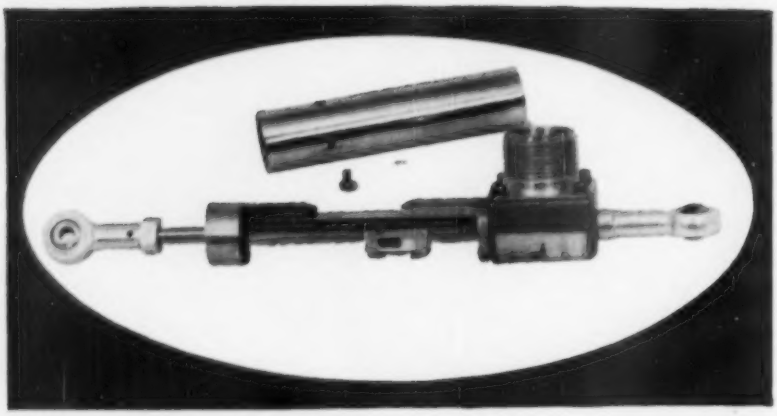

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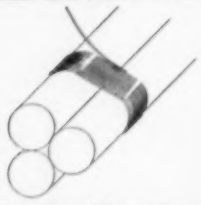
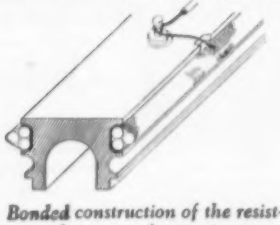
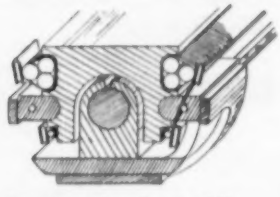


Micro spot weld tap connections (guaranteed single turn connections).



Bonded construction of the resistance element to frame gives new ruggedness.



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aboard Flight 2 as an additional crew member without flight crew duties.

Hostess Tracine E. Armbruster was employed by the company April 24, 1950.

Hostess Beth E. Davis was employed July 7, 1953.

• United Air Lines.

Captain Robert F. Shirley, age 48, was employed by United Air Lines July 22, 1937, and was promoted to captain November 1, 1940. During his employment he accumulated 16,492 flying hours, of which 1,238 were in the DC-7. He held a valid airman certificate with, among others, currently effective airline transport and DC-7 ratings. Captain Shirley completed his last first-class physical March 8, 1956. Prior to the subject flight he had a rest period of 63 hours. Captain Shirley was qualified over the route involved and had flown it on a regular basis since October 1, 1955.

First Officer Robert W. Harms, age 36, entered the employment of United Air Lines February 7, 1951. He held a valid airman certificate with airline transport and DC-7 ratings. First Officer Harms was captain-qualified on the DC-3. He had a total of 4,540 flying hours, with 230 in the equipment involved. He received a CAA physical examination on May 28, 1956, and prior to Flight 718 of June 30, 1956, had 155 hours of off-duty time.

Flight Engineer Gerard Fiore, age 39, was employed March 26, 1948, as a mechanic. He became a flight engineer February 22, 1951.

He held a currently effective mechanic certificate with airframe and engine ratings, and a valid flight engineer certificate. Mr. Fiore had accumulated 2,670 flying hours since March 1, 1953, when records of the company became effective on engineer personnel. During this time he flew 285 hours in the equipment involved.

Stewardess Nancy L. Kemnitz was employed by the company February 28, 1954.

Stewardess Margaret A. Shoudt was employed September 1, 1954.

The Aircraft

• Trans World Airlines.

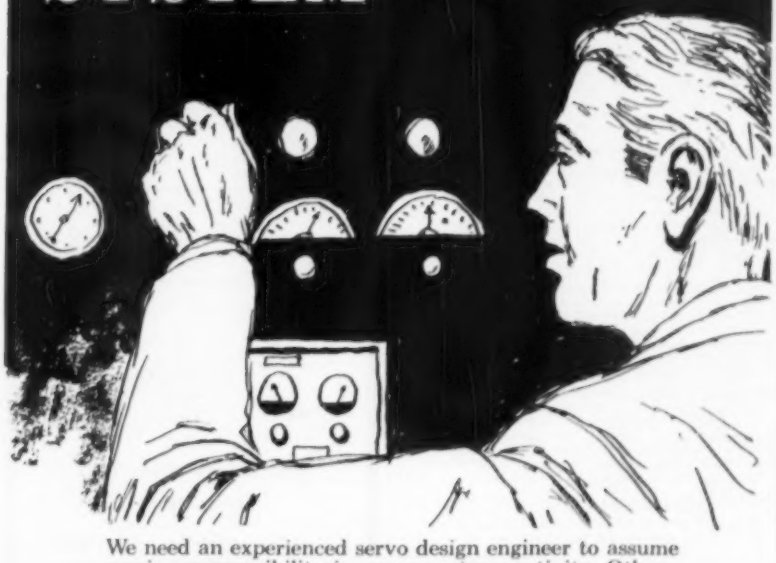
N 6902C, a Lockhead Constellation, model 1049A (covered in CAA aircraft specification No. 6A5 under the heading Model 1049-54), bore manufacturer's serial number 4016. The aircraft was placed in service by the company May 22, 1952, and had a total of 10,519 flying hours, of which 2,017 hours were accumulated since the last major overhaul, with a line maintenance check accomplished just prior to Flight 2 of June 30, 1956. The aircraft was equipped with Wright engines, model WAD975C18-CB-1, and Hamilton Standard propellers, model 43E60 with model 6901A-O blades.

• United Air Lines.

N 6324C, a Douglas DC-7, was purchased by United Air Lines January 10, 1955. It bore manufacturer's serial number 44288 and company number 9124. The aircraft had been flown 5,115 hours, 1,125 of which were accumulated since its last overhaul.

A line maintenance check was completed before origination of Flight 718 of June 30, 1956. The aircraft was equipped with Wright engines, model 972TC18-DA-2-4. The propellers were Hamilton Standard 34E60 with model 6921C-8 blades.

SERVO DESIGN and SYSTEM ENGINEERS



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SYSTEM EVALUATION ENGINEER
Establish engineering requirements and investigate design approaches. Plan and direct the preparation of specifications for special in-plant test and evaluation facilities on centrifuges, scorsbys, complex wave simulators, sidereal tables and digital computers. Liaison between subcontractors and company.

DESIGN ENGINEER — GROUND EQUIPMENT
Design and development of production test and field test equipment where specific objectives and general requirements are known in the electrical and mechanical engineering fields. Must have experience on design or development of electromechanical instruments.

DATA PROCESSING AND REDUCTION ENGINEER
Responsible for establishing overall data reduction procedures. Direct the activities in specifying and procuring all components of standard automatic digital and analog data handling and processing equipment. Responsible for design or procurement of special data processing equipment.

FUNCTIONAL ENGINEERS — MISSILE SYSTEMS
Develop inertial guidance systems including gyro, accelerometers, integrators, servo systems and computers. Analyze functional problems arising during development and evaluation of said system.

ELECTRO-MECHANICAL ENGINEER
Conduct investigation on special electromagnetic and electromechanical devices including evaluation and/or design of transducers, servo systems and related devices.

GROUND EQUIPMENT ENGINEER
Plans and performs engineering studies, basic electrical and mechanical design, development and evaluation of production test and field test equipment where specific objectives and general requirements are known. Must be familiar with electromechanical instrumentation.

TRANSISTOR CIRCUIT ENGINEER
Pulse application of high speed transistors used in airborne digital computers. Circuit design applications requiring knowledge of latest transistors such as tetroids and superficial barriers.

DIGITAL COMPUTER ENGINEER
Basic research and development including logical design, dynamic analysis, component development, hardware and packaging, system and component reliability, and laboratory and field evaluation of complex computers for fire control and guidance systems.

FIELD EVALUATION ENGINEER
Perform overall planning functions for field evaluation of missile guidance systems. Direct activities in scheduling the field operations. Liaison with field test site agencies and formulating overall operating procedures at test site on missile project.

PROJECT ENGINEER — AIRBORNE EQUIPMENT
Project engineering of computers, pro and anti submarine fire control equipment, airborne navigation plotting equipment and similar equipment. Preparation and proposals on equipment of such types.

PRODUCT ENGINEER
Initiate, compile and maintain design standards on electrical, electronic and mechanical design subjects pertinent to fire control equipment and inertial guidance components. Must have considerable responsible experience on product design standards covering areas indicated in job studies.

DEVELOPMENT ENGINEER — RADAR
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To conduct vibration, shock and acceleration tests on electromechanical components and systems. Analyze results and develop equipment to conform with specification requirements.

ENVIRONMENTAL TEST ENGINEER
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To plan, conduct and report upon development studies of finishes, materials and processes, which will be incorporated into the design of electromechanical and electronic components and systems.

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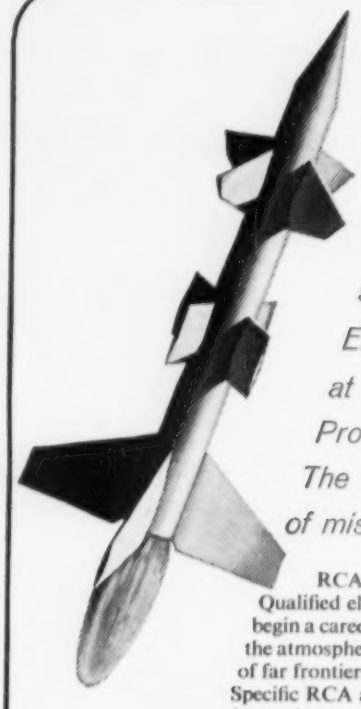

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		• Servo-mechanisms and Feedback Systems
		• Analog Computers
		• Military Specifications
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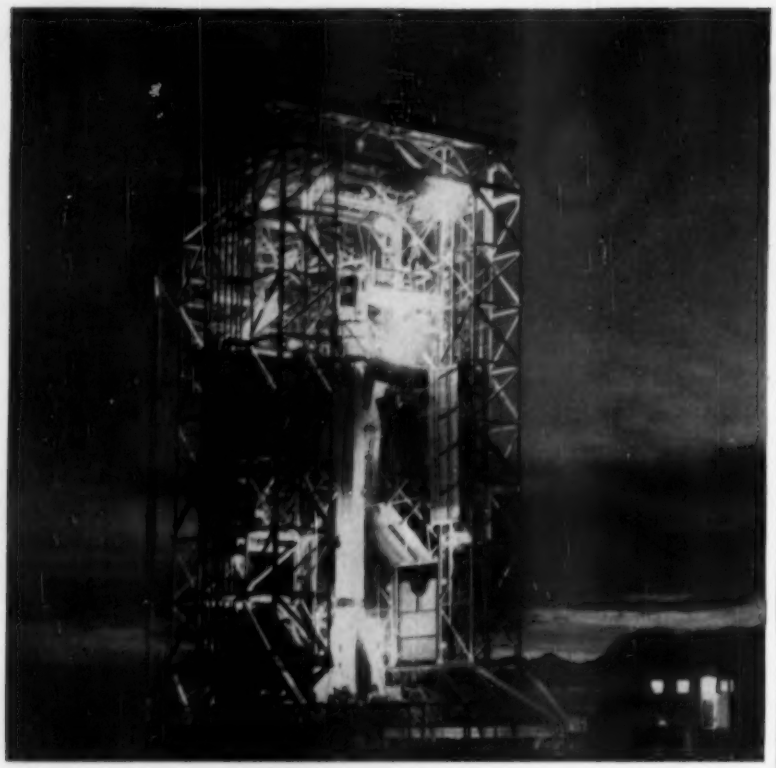

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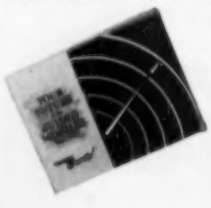

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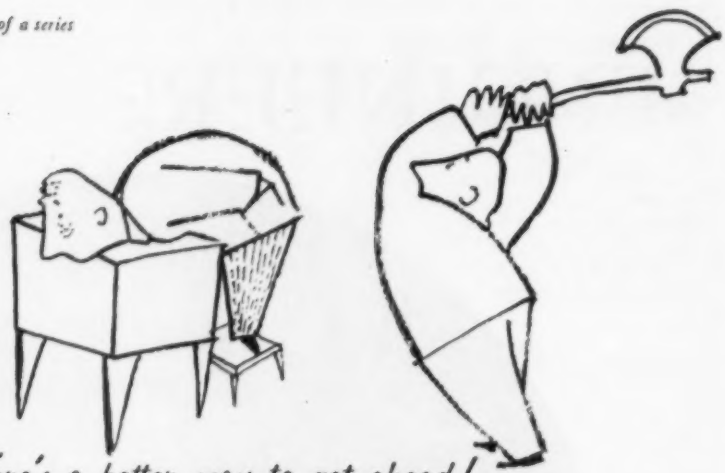

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LETTERS

"Sad Hiring Case"

I wish to say "hats off" to Capt. Robson's column, "How to Hire a Pilot," in your April 1 issue (p. 45). Mine is just one of many of the sad cases concerned with the hiring of pilots.

I served as Aircraft Commander in MATS for three years and also as instructor pilot on DC-4s. When I was released from active duty I returned to college to complete my third year. I had always been interested in aviation and decided to try my luck with the airlines.

Well, I was sent out west to take one of those "Pilot Elementary Tests," and I didn't make the grade. It seems that a big factor against me was the fact that I have always enjoyed swimming more than baseball and, of course, this would make me an unsafe pilot because swimming is more or less an individual sport whereas baseball is a team sport. Gotta have team work in the cockpit.

My next try was with a well-known Southern line. Their test consisted of numerous repetitious, nonsensical questions that had to be answered simply "Yes" or "No." Well, it looks as though I said yes when I should have said no. Questions on this test had nothing whatsoever to do with aviation, but they were keenly interested in: "Do you often have the urge to kill your grandmother?" "Do you often think that you can do the job better than the boss?" etc.

About a week after completing the test I received a letter stating that I didn't come up to their standards in the exam and that, once again, I had had it.

Since I had passed my 30th birthday, I was rapidly approaching the age limit for this young man's profession, so I decided I might better qualify if I got an ATR.

I rented a ship at $75 per hour and got an ATR with one of the most senior captains on this Southern line, who is also a CAA designated check pilot. I figured nothing would be better to enhance my chances with this line than to have one of their senior captains give me a full ATR check.

At my own expense I journeyed down to the Mecca of supermen and waited patiently in the chief pilot's office for four hours. I felt sure that my letter of recommendation from one of their own plus the ATR would do it, even though I still didn't want to kill my grandmother. The moment finally arrived—all was ready for this beggar to meet the master. He gave me about five minutes of his valuable time and started on a new kick.

This time I was ½ in. too short. This was really a laugh because this character came up to my chin.

Well, I took the advice that Capt. Robson stated in his column, ". . .walk across the street." I got a job with a scheduled airline that was interested in hiring pilots. I had a short interview with the chief pilot and then went up for a ride to see what I could do.

I started in the next copilot class and two years later checked out as captain.

It seems to me that it's an awful slur against the U. S. Government the way they test ex-military pilots. I spent one solid week on psychological and psychomotor tests after I had been selected for pilot training. I should think that if I was good enough to be selected for training in the USAF, costing many thousands of dollars plus a year's training, that I should be qualified to complete the airlines' ground school so that I might be able to pull gear for one of those old Southern supermen who at times find it hard to line up with the runway.

HIRED PILOT

Aviation Week welcomes the opinion of its readers on the issues raised in the magazine's editorial columns. Address letters to the Editor, Aviation Week, 330 W. 42 St., New York 36, N. Y. Try to keep letters under 500 words and give a genuine identification. We will not print anonymous letters, but names of writers will be withheld on request.

GCA Crash Role

Your excellent article ("Ground Control Faulty in Vulcan Crash;" AW March 11, p. 111) giving the full report of the British Accident Investigation Board on the Vulcan crash, together with Major Liebman's letter to the editor (AW April 29, p. 140), may have inadvertently given an erroneous impression concerning GCA equipment now in use around the world.

The GCA equipment in use at civil airports in Great Britain is the 1944 MPN-1 model. This original equipment utilizes two surveillance scope operators and three operators for the final approach function. The GCA equipment at the London Airport requires the use of an elevation tracker operator to follow the aircraft target by turning a mechanical handcrank to activate a mechanical cursor on the elevation scope.

This elevation information is then transmitted to an elevation error meter at the final controller position.

Such mechanical tracking is adequate for aircraft with approach speeds and flying characteristics of the 1944 vintage.

The larger and faster jet aircraft need modern GCA equipment to provide instant altitude data directly to the final controller.

In the AN/CPN-4 GCA equipment developed by our company for the USAF in 1948, elevation, azimuth and range of the aircraft is displayed directly on the final approach Az-El scope.

This three-dimensional display gives continuous and instantaneous information on the aircraft's position to the final controller at all times during the final approach. It eliminates the need for an elevation or azimuth tracker.

The three-dimension Az-El scope technique was also employed in our development of the original PAR GCA equipment for the CAA and has been in continual use at all major CAA airports in the U. S. since 1950.

Over 400 GCA equipments, the AN/CPN-4, the AN/MPN-11, and the AN/FPN-16, all developed and produced by our company, are the standard GCA equipment for the U. S. Air Force, the U. S. Navy, the U. S. Marine Corps, the U. S. Army, the Royal Canadian Air Force, the Royal Australian Air Force, the South African Air Force, the Japanese Self-Defense Force, the British Royal Air Force, the British Royal Navy, and all of the NATO nations, totaling thirty-three countries around the world.

At a recent air navigation conference here in Los Angeles, an Air Force general, who is a pioneer in USAF electronics, accurately summarized the meeting by observing that electronics personnel in military and civil aviation must have the courage to obsolete electronic equipment designed and produced in WW II as readily as tactical military personnel have obsoleted P-38s, P-40s, P-51s, B-17s, Spitfires, Hurricanes, etc.

GCA has established a superb safety record during the past 14 years and will continue to maintain its history of safety with modern jet traffic only if available modern GCA equipment is provided to those unsung heroes, the GCA operator and the GCA maintenance man.

LEONARD DAVID CALLAHAN
Vice President
Gilfillan Bros. Inc.
Los Angeles, Calif.

SPCA for Passengers

As a passenger who has suffered innumerable discomforts as a result of airlines failing to provide the service they advertise including reasonable adherence to their published schedules I would like to call your attention to the following case of an irate airline passenger and his successful suit against British European Airways and Air France as reported in the Manchester Guardian. The report follows:

"A company chairman and his wife and daughter who were looking forward to a lunch with champagne on a flight from Paris were given seats on a later aircraft instead and served with lukewarm tea, buns, and slab cake. Their counsel, Mr. R. O. C. Stable, said this at Westminster County Court yesterday when Mr. and Mrs. Gilbert Colona-Chalmers, of Sea Avenue, Rustington, Sussex, were each awarded £30 damages against British European Airways and Air France for breach of contract.

Mr. Stable said the flight was to have been the "high-light" of the family's week's holiday in Paris in April last year. The journey was advertised as an 'epicurean flight' and included a free champagne lunch. 'It conjures up a wonderful picture of French cooking,' he added. The family boarded the noon aircraft at Orly Airport but were then ordered off and the plane left soon after with their luggage. Mr. Stable said there had been a double booking."

You may know that Lord Barbazon of Tara has organized an Association of International Air Travellers aimed at protecting the passenger's rights against airline default. I think this organization should be extended to the United States where airline passenger service seems to be steadily deteriorating.

IRATE PASSENGER
GENEVA, SWITZERLAND

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Accurate device *output* demands accurate power *input*, and in 400-cycle equipment—vital in today's aircraft and missiles—accuracy is everything. For the *precise* input power needed in designing, manufacturing and checking out of modern avionic systems, it's a growing habit to buy LEACH (INET-Palmer) 400-Cycle *Precise* Power...complete packages, ready to "plug-in."

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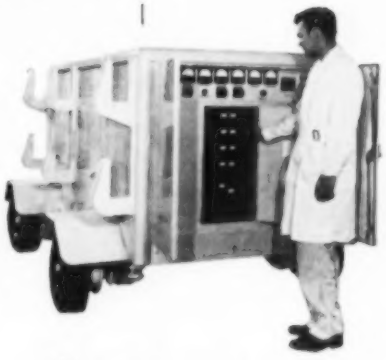

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Overload Rating.....125% for 3 minutes

Regulation:
Frequency...400 cps ±0 cps with 60 ± cps input
Voltage..... ±1% (±½% optional)

Recovery Time.....to 20 KVA – .150 sec.
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Voltage Modulation.....less than ¼%

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Wave Form.....3% rms total harmonic content (2% optional)

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Complete specifications are listed in Leach's new brochure on 400-cycle motor-generator sets. Send for your copy today.

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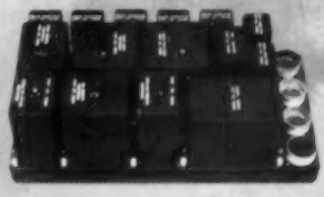

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